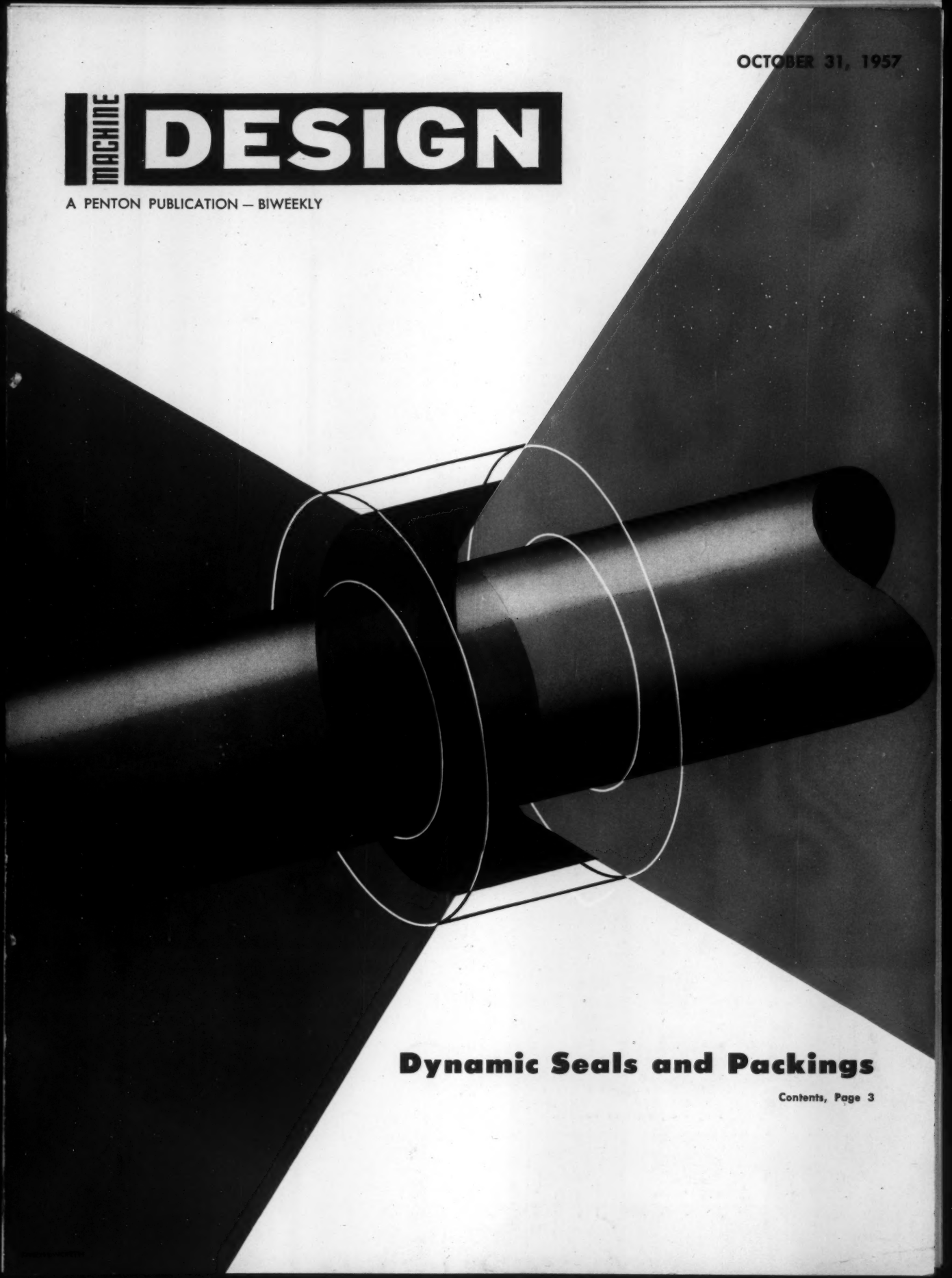
OCTOBER 31, 1957

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Dynamic Seals and Packings

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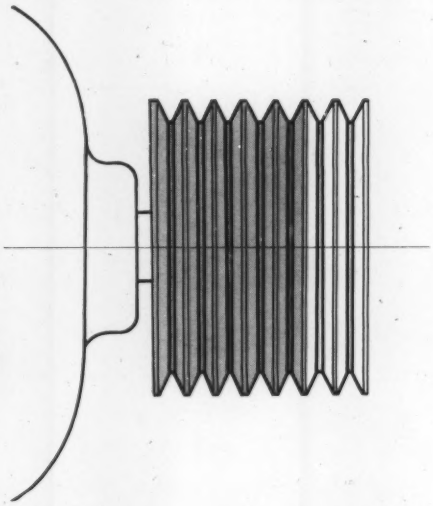
5 Gates Super Vulco Ropes do the work of 7 standard V-belts

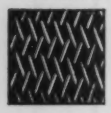
Use fewer belts...

but get same HP



No other V-Belt has ALL these advantages

1. Flex-Weave Cover (U.S. Pat. 2519590)

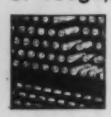


A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer . . . increases belt life . . . more power available to driven machine.

2. Concave Sidewalls (U.S. Pat. 1813698)

Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt . . . far longer belt life.

3. Tough, resilient Tensile Cords



Super strong resilient tensile cords provide 40% greater horsepower capacity . . . easily absorb heavy shock loads . . . reduce number of belts required . . . save weight and space.

4. High Electrical Conductivity

Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant

Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

Cut sheave width and weight . . . design your drive to benefit from the greater HP capacity of Gates Super Vulco Ropes.

Gates Super Vulco Rope has 40% more horsepower capacity . . . delivers more HP per dollar invested than any standard V-belt. 5 Gates Super Vulco Ropes will do the work of 7 standard V-belts.

Sheaves with fewer grooves cost less . . . weigh less . . . occupy less space. Your drive design is improved.

Helpful drive data is quickly available to you. Simply call your nearby Gates distributor for advice from a Gates V-Belt Specialist. Stocks carried in industrial centers throughout the world.

The Gates Rubber Company
Denver, Colorado

TPA 264A

Gates — The Mark of *Specialized* Research

Gates Super VULCO ROPE Drives

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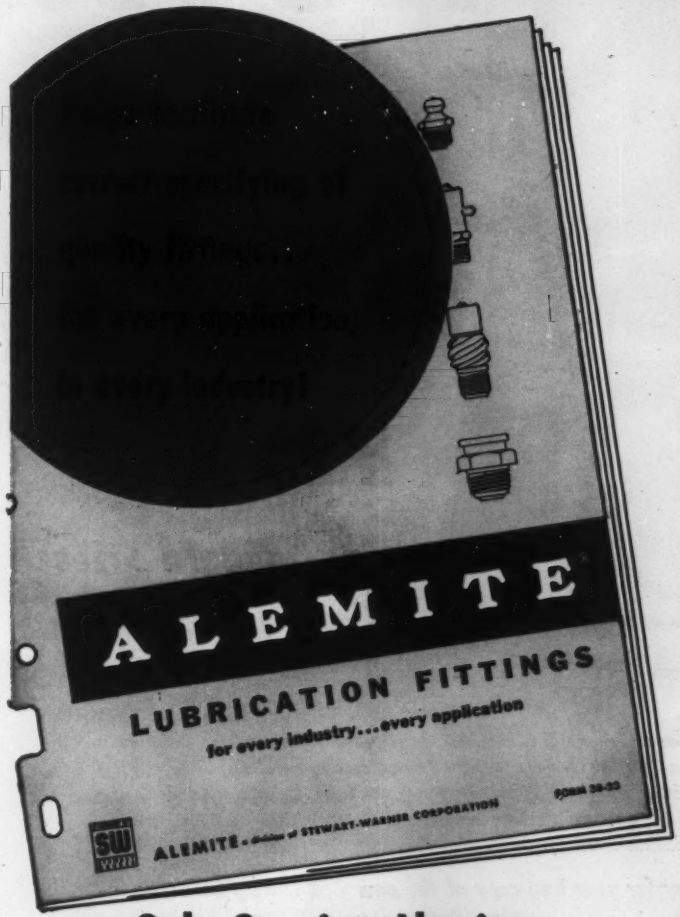
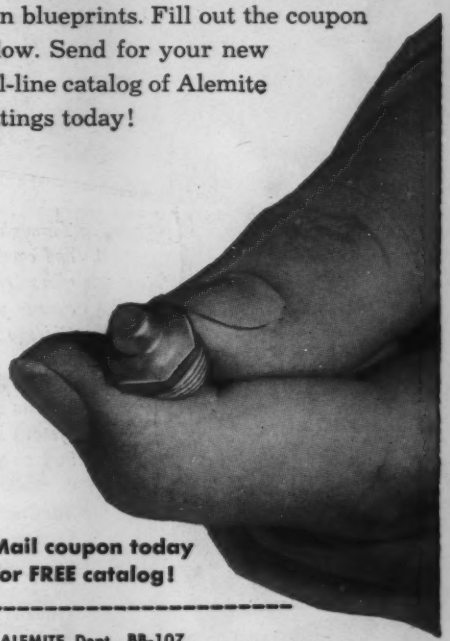
FREE! New Full-Line Catalog of
ALEMITE Lubrication Fittings!



Here is Alemite's new free catalog of the most *complete* line of fittings on the market! A simple, handy guide to fast, easy selection of the right fitting for every requirement. Contains detailed drawings of all Alemite fittings including the famous Alemite "Red-Ball" Hydraulic Fittings. Also lists many types of fittings that have been developed for special purposes—including relief fittings, measuring fittings and drive fittings. Complete with individual dimensions—ready for transfer to your own blueprints. Fill out the coupon below. Send for your new full-line catalog of Alemite Fittings today!



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4. Extra-thick wall gives unequalled strength—withstands hard field service!

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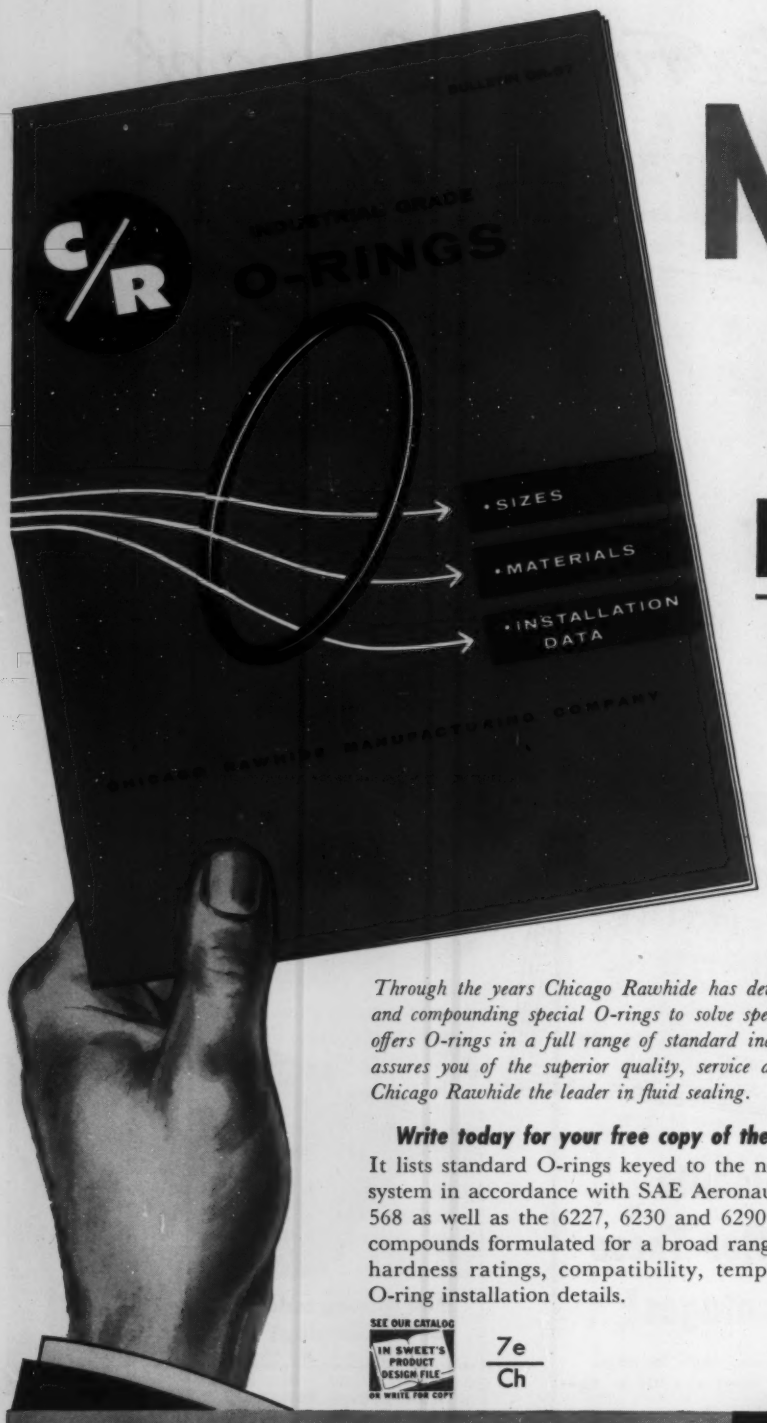
Address.....

City..... Zone..... State.....

Circle 404 on page 19



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Write today for your free copy of the new C/R O-Ring Bulletin.
It lists standard O-rings keyed to the new, uniform dash numbering system in accordance with SAE Aeronautical Recommended Practice 568 as well as the 6227, 6230 and 6290 series sizes. It also lists C/R compounds formulated for a broad range of industrial purposes with hardness ratings, compatibility, temperature ranges, and typical O-ring installation details.

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O-RING C/R DIVISION
CHICAGO RAWHIDE

October 31, 1957 Volume 29—No. 22

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

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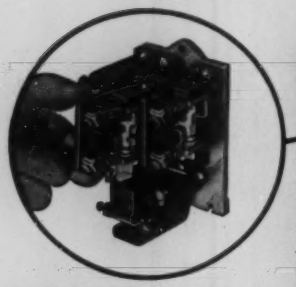
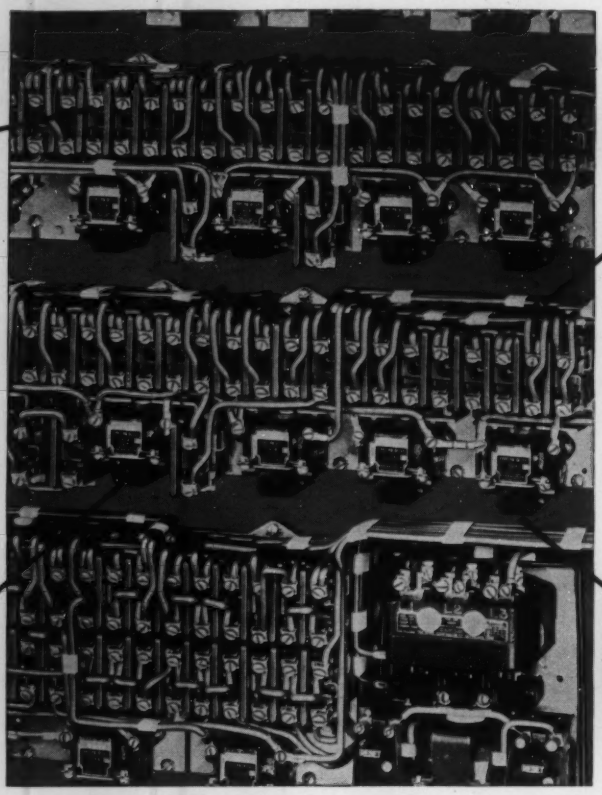
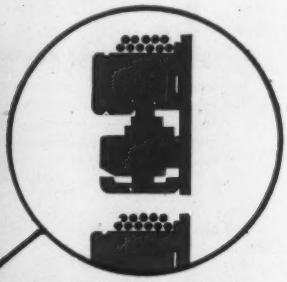
Why CLARK Type "PM" RELAYS give you more contacts per square foot of panel space!

Unique Features Produce Rugged Yet Compact Heavy-Duty Relay...

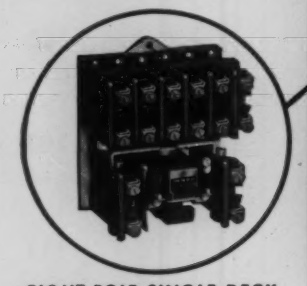


SECTIONAL POLE CONSTRUCTION. A Clark exclusive... With each pole in its individual melamine chamber, space between relays for electrical clearance is unnecessary. Front-mounted terminals eliminate need for extra side clearance. Sides of contact blocks are flush with edges of mounting plate.



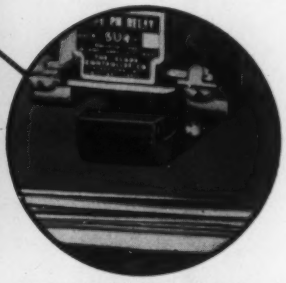


BUILT-IN WIRING SHELF... The melamine tops of the pole assemblies provide an insulating shelf free of current-carrying parts. Wiring can be bundled or laid flat right on top of the relay, saving additional space between rows. When wiring troughs are desired, they can be placed much closer to the top of the relay. This feature is another Clark exclusive.

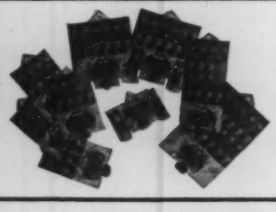


EIGHT-POLE SINGLE DECK... Only Clark makes it possible to have an eight-pole relay with single-deck wiring. At the same time, it uses every square inch of space on mounting plate, and lines up perfectly with Clark 2, 3, 4 and 6-pole single deck relays.

UNIFORM DIMENSIONS... Clark type "PM" relays are an integrated line designed so that they can be mounted side by side in perfect alignment with each other. In addition, the double-deck models have identical mounting dimensions with Clark type "CY", size 1 starters. Result: Neater, more uniform and more compact control panels.



⅞" MAGNET CLEARANCE... That's all the space needed to remove magnet and change coil. In overall panel construction and layout, this feature saves space by reducing amount of space between rows.



FREE TEMPLATES!

FREE TEMPLATES! Write for kit of actual-size photo-templates of type "PM" relays mounted on heavy cardboard. A great time-saver in laying out control panels. Each template has detailed dimension drawing and pole arrangement on the back.

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Circle 406 on page 19

Engineering News Roundup

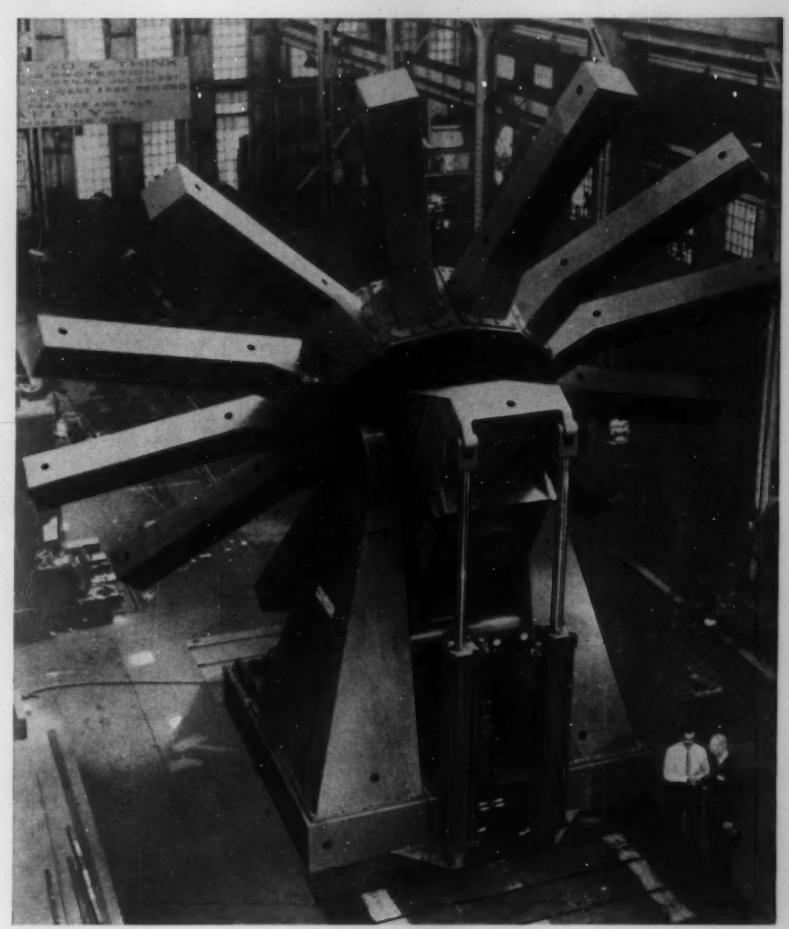
Company President Earns High Salary; Works for It

AMA Survey Shows Degree, Broad Scope Key Combination

NEW YORK — The "typical" company president is 50 years old, earns $68,000 a year, and works 10 to 15 hours beyond his company's normal work week. His company's sales average $65 million annually, he holds a college degree, and he's a family man.

This composite portrait of a company president is drawn from a recent survey by the American Management Association. Since all presidents included in the survey are AMA members, they represent a somewhat select sampling, probably above average in both education and income.

Of 335 presidents interviewed, 304 are married. Individual salaries ranged from $13,500 to $400,000, company sales from less than a million a year to several billion. Most frequent route to presidency was by way of diversified experience in marketing, production, and finance. Seven out of ten graduated from college. Degrees in the sciences outnumber those in the arts by ratio of three to two.



WINDMILL WELDING POSITIONER, the largest machine of its type in existence, will be used for big welding jobs at Navy's Mare Island Shipyard. Weighing 100 tons, the positioner stands 21 ft high. Its rimless spoked table, 33 ft in diameter, is turned by two electric motors. A 2 hp motor operating at 0.005 to 0.05 rpm is used for slow, forward, and reverse speeds. A 7½ hp motor provides rapid traverse. The table can be tilted at any angle up to 60 deg by a 2000 lb hydraulic system. The positioner was designed by Pandjiris Weldment Co.; built by Bethlehem Pacific Corp.

Mach-150 Shock Waves Aid Study of Ionized Gases

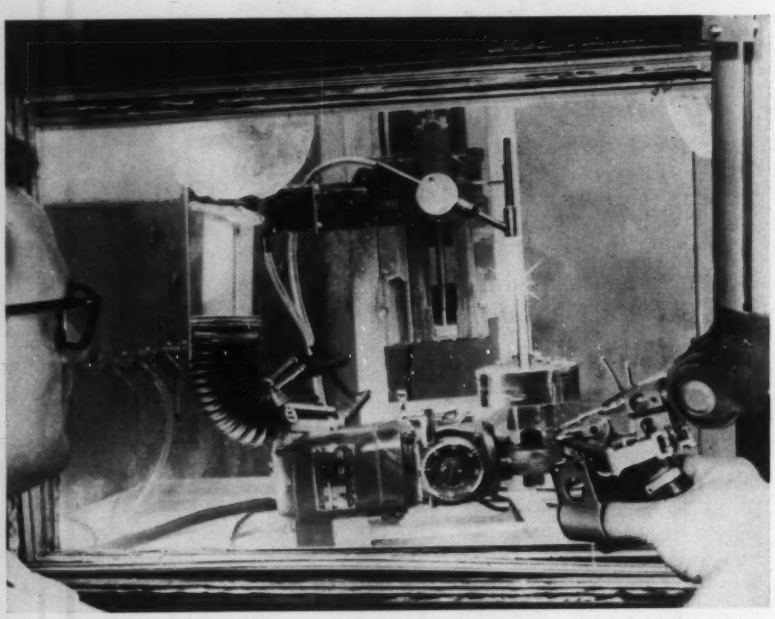
100,000 C Gas Discharge Achieved in Shock Tube

LOS ANGELES—High velocity shock waves in the laboratory have reached speeds of more than 100,000 mph. Well above Mach 150, these velocities are among the fastest ever reached under controlled laboratory conditions. The swift shock waves, which also produce temperatures higher than 100,000 C, have been created in an advanced hydromagnetic shock tube built by Lockheed's Missile Systems Div.

At one end of the tube, a large, high-voltage discharge from a bank of condensers creates a bubble of superheated gas. Expansion of the hot bubble produces a high-veloci-

ty, intensely luminous shock wave which flashes down the tube. External magnetic fields boost the wave to tremendous speeds and temperatures.

This research provides valuable data on the flow of highly ionized gases at extreme Mach numbers and temperatures. To obtain the velocity and temperature measurements, new techniques involving photoelectric, spectroscopic, and microwave systems have been developed. These studies should provide information on the properties of superheated gases of importance to the science of hypersonic ballistic missiles. It is expected that some of the results will have application to outer space travel.



REMOTELY CONTROLLED WELDER SEALS RADIOISOTOPE in capsule. Looking through protective glass, technician controls inert-gas, shielded-arc, welding unit at Oak Ridge National Laboratory. Unit's major components include conventional welding power supply and remotely operated assembly. The latter, placed in a shielded cell equipped with mechanical manipulators, has motor driven positioners for both the torch and containers. Equipment, developed by Union Carbide, seals cylindrical stainless steel capsules for various industrial applications.

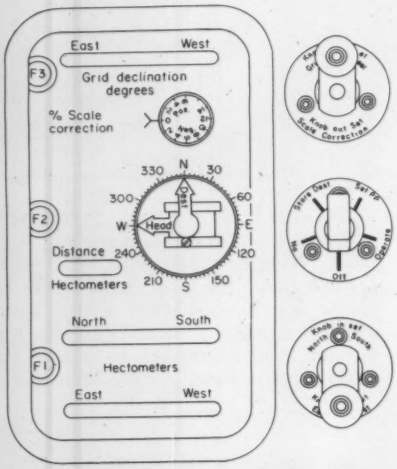
Automatic Land Navigator New for Army's Tanks, Trucks

Unmapped Terrain, Darkness No Problem for New Black Box

WASHINGTON, D. C.—Navigation of land vehicles under the most adverse terrain conditions will be easy with a new electronic device recently acquired by the Army.

Small in size—6 x 8 x 12 in.—the instrument is accurate to within 0.2 per cent and operates within a radius of 600 miles without recalibration. Called the Automatic Navigation Computer for Land and Amphibious Vehicles, it was developed by Ford Instrument Div., Sperry Rand Corp., and the Army's Research and Development Laboratory.

In operation, the new black box requires two automatic inputs; one from an odometer or driveshaft and the other from a gyro compass. By simple adjustment of two knobs all other necessary information is introduced into the computer. These manual inputs consist of *grid declination*, which compensates for deviation of the map grid from true north; *scale correction*, which adjusts for sloping terrain, tread wear, and slippage; and *set destination*, the rectangular co-ordinates of a preselected destination. One further setting, the alignment of the computer present position co-ordinates with respect to a map grid, or home base, is made before starting, and the computer operates automatically thereafter.



Instrument display on Army's new land navigator literally points to a preselected destination. The new device is small, accurate, rugged, and exceptionally easy to operate.

Under way, the driver merely watches his data presentation. It informs him of his vehicle heading, the correct destination heading, and the distance from his present position to the destination. If the two heading arrows are superimposed on the display, he is headed for his destination by the shortest possible route. If some terrain feature forces him to detour, he swings around the obstacle and gets back on course by again matching up the two arrows.

Front Cover

Whirling fluid cones find passage blocked along a shaft surface in artist George Farnsworth's idealized conception of the function of dynamic seals and packings. Inspiration for this simple theme was taken from John Holt's and Bill Miller's comprehensive treatment of this subject, beginning on Page 69.

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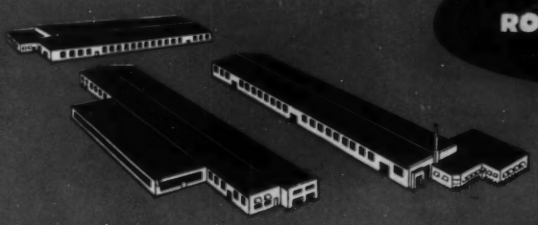

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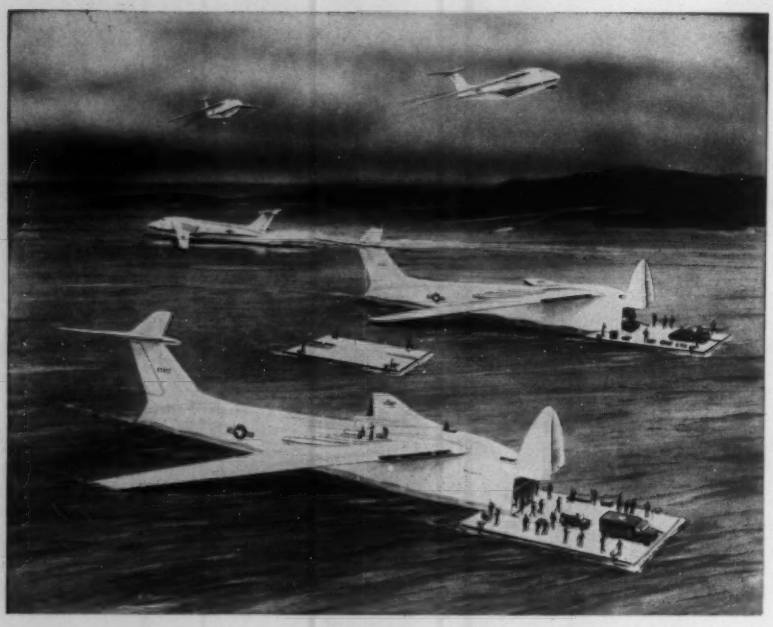

SEAPLANE AIRLIFT could utilize global waterways to provide new speed and mobility for moving troops and supplies, according to Martin Co. Jet-powered transports pictured here would have 8 to 10 engines; gross weight of 200 to 300 tons. Sizeable payload might consist of 400 passengers, three light tanks, or a fully equipped infantry company with supplies for 3 days. Terminal facilities carried aboard would include self-propelled lightering rafts and pneumatic U-docks. Supplies prepackaged in floating boxes could be emptied directly into the water for fast pick-up by helicopter. On long range missions, refueling could be accomplished in flight.

Foresees $5 Billion Savings In 1962 Thru Peacetime Atom

AEC Member Urges UNations Adopt More Safe, Cheap Uses

PARIS, FRANCE—Radioisotope uses saved U. S. industry $100 million in 1953, $406 million in 1957, and promise to save $5 billion in 1962, according to Dr. W. F. Libby, member of Atomic Energy Commission, in a recent address before UNESCO.

Dr. Libby presented data documenting the burgeoning peacetime use of atomic energy. The accompanying table, "Rate of Industrial Savings," shows variety of industrial uses, and estimated dollar savings from each.

Included in his address to representatives of foreign nations was "Please help me. Go home and tell everyone that isotopes are wonderful, that they can do many, many useful jobs, and that they are safe and cheap."

Radioisotope Annual Savings

(Estimated as of July 1957; values in $1 million)

Use	Low	High
Cigarette density gages	42.7	57.0
Metal thickness gages	18.5	27.8
Rubber and tire fabric thickness gages	8.0	20.3
Plastic and adhesive thickness gages	2.0	6.1
Paper and allied products thickness gages	23.1	24.9
Other thickness gages	2.3	6.9
Gages such as liquid level, moisture, H-C ratio, snow, etc.	2.5	7.6
Radiographic testing	28.7	64.6
Oil well logging	16.0	24.0
Oil well stimulation	120.0	180.0
Pipeline oil flow	0.5	0.7
Petroleum refining	5.3	10.1
Other applied industrial tracing	12.5	25.0
Tool wear studies	0.8	1.2
Piston ring and similar wear studies	12.0	18.0
Corrosion studies	3.0	4.6
Other industrial research	12.0	18.0
Luminescent sources	1.7	2.7
Miscellaneous industrial applications	0.5	0.8
Total	312.1	500.3
Average	406.2 ±100	

Topics

Radio waves replace a green thumb in seed-sprouting experiments at Washington State College. The scientists use high-frequency waves to crack the hard shells of seeds such as sugar peas and alfalfa, the purpose being to promote simultaneous sprouting and, consequently, a uniform rate of plant maturity.

• • •

Speed increases volume of an automobile horn recently patented by Chrysler Corp. The system, linked to the car's drive shaft, produces a conventional beep from a pair of "city" horns below a certain speed. Above this rate a third, louder horn adds its voice to sound a stronger, longer-range warning.

• • •

Calling up—literally—can be accomplished over a public air-to-ground telephone system being tried over the Detroit and Chicago areas. Calls are handled through "aviation" operators at Michigan Bell and Illinois Bell telephone companies. The Federal Communications Commission has authorized a one-year test of air-to-ground facilities to determine feasibility of the service. At present, only a few planes of private companies are equipped.

• • •

The planet NORC has been named after the Naval Ordnance Research Calculator, the Navy's fastest and most powerful electronic computer. NORC's orbit was established entirely on the basis of computations made on the computer.

• • •

World's first and only vapor-cooled transformer in commercial operation is a 500-kva, gas insulated submersible unit operating on the network system of the Consolidated Edison Co. of New York. The transformer was developed by Westinghouse Electric Co.

• • •

Aluminum cans have been placed on the market by Continental Can Co. Cans made in the conventional way are available now; those formed by impact extrusion will be offered next year. Continental does not expect aluminum to replace the old, reliable tin can but foresees its use in containers requiring visual appeal.

NEW DIAMOND CATALOG 37

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☐ **Please send me a copy of the new Diamond Catalog No. 37.**

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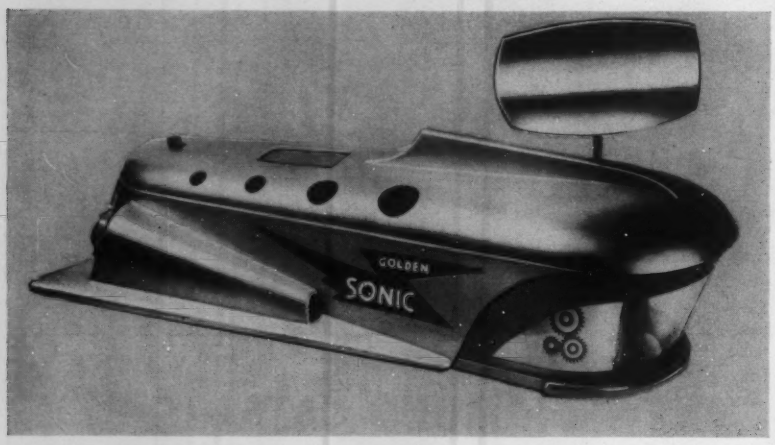
Company Name_____

Address_____

City_____ Zone_____ State_____

Circle 408 on page 19



DRIVERS JUST WHISTLE to control this "space" vehicle made by Tigrett Industries. Golden Sonic is 8 in. wide, 19 in. long, 10 in. high; operates indoors or out. Its "radar" is sensitive to certain-pitched sound, turns vehicle in direction of source. Manufacturer supplies "super-sonic" whistle.

Space Age Seen in Toys for '57

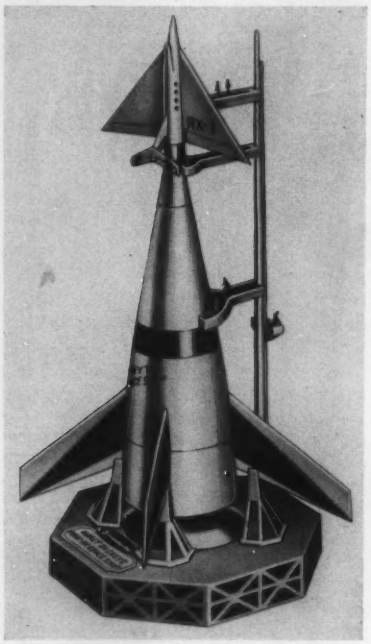
Suited to the times, U. S. toy designers have brought out their own space-station launcher, truck mounted, and another vehicle that projects images of flying targets and carries a "rocket launcher" to bring them down. Many manufacturers feature such conceptual, child-size, space-age equipment.

This is probably the dominant trend in American toys for 1957. It is apparent in this and the next two pages which complete MACHINE DESIGN's coverage of new electrical and mechanical toys for the current season.

More realism is another trend characterizing most new toys. Trains are particularly good copies of full-size counterparts.

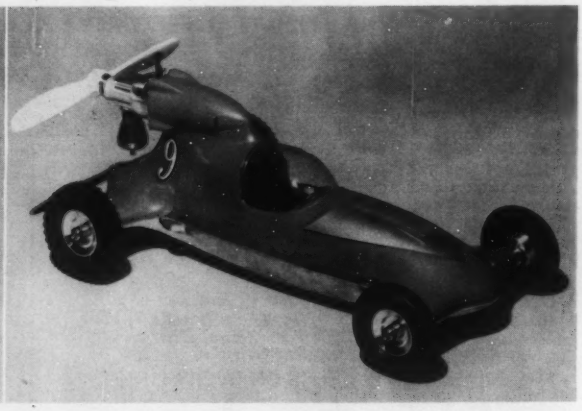
Real engines, single-cylinder, internal-combustion types, add realism to performance of vehicles and airplanes. Wen-Mac Corp. offers boats, planes, and cars thus powered.

Construction sets, in addition to the long established lines, include Main Street plastic blocks by Gibbs Automatic Moulding Corp.



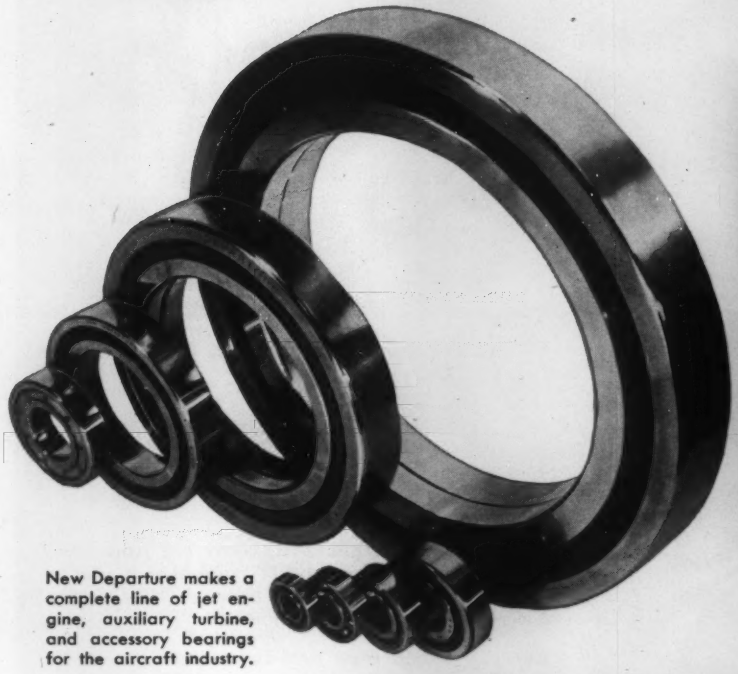
MULTISTAGER as conceived by Walt Disney is reproduced as a 61-piece plastic model by Strombeck-Becker Mfg. Co. Same manufacturer offers a tire-like space station, 8 in. wide, of 35 plastic parts.

HYDROPLANE RACER is called Water Wizard by its maker, L. M. Cox Mfg. Co. Powered by miniature gasoline engine, driven by scale propeller, the racer can be run free or tethered to run in a circle. The 15-in. plastic boat can take sloping beach head on—it goes faster on wet, hard, sand than in water.

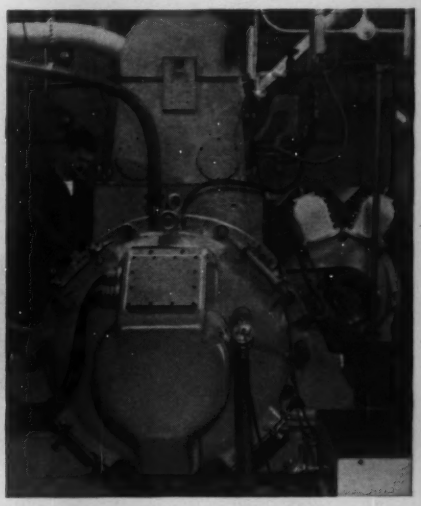


PROP-ROD is powered by a miniature airplane engine which drives a scale propeller. Rear tires have racing tread for appearance only. Underframe, including axle bearings, is cast aluminum; remainder of body, plastic. Overall length is 12 in. Made by L. M. Cox Mfg. Co., Prop Rod can be run free or tethered.

ND FACTS

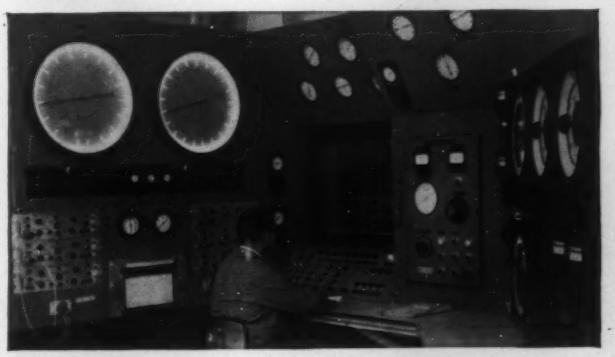


New Departure makes a complete line of jet engine, auxiliary turbine, and accessory bearings for the aircraft industry.



Test stand for running jet engine ball bearings at high speeds, high temperatures under heavily loaded conditions.

RESEARCH NEVER STOPS!



Instrumentation and control console for test stand shown above, for testing full-scale mainshaft ball bearings.

Tomorrow's needs are today's concern at the aircraft ball bearing research facilities at New Departure. For, the future development of the ball bearing will be closely identified with future engine design trends. This means New Departure spares no effort in developing bearings to operate at higher speeds, heavier loads, and under higher temperatures with good bearing-life predictability.

As always, New Departure keeps pace with changing conditions in the industry. For New Departure's design and fabrication processes for current high-speed, high-temperature, heavily loaded ball bearings are major factors in the successful operation of today's jet engines, as well as auxiliary turbines and accessories.

For aircraft and accessory bearings, send for **CATALOG ABC.**

For data on research progress for jet engine bearings, send for **REPRINT JEB.**

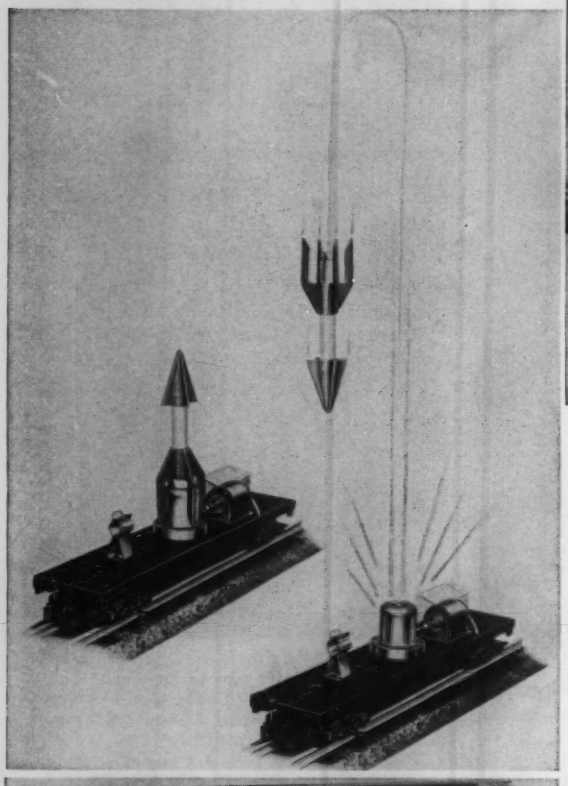
GM FORWARD FROM FIFTY

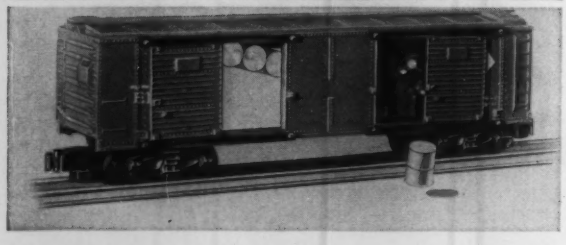
ND NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

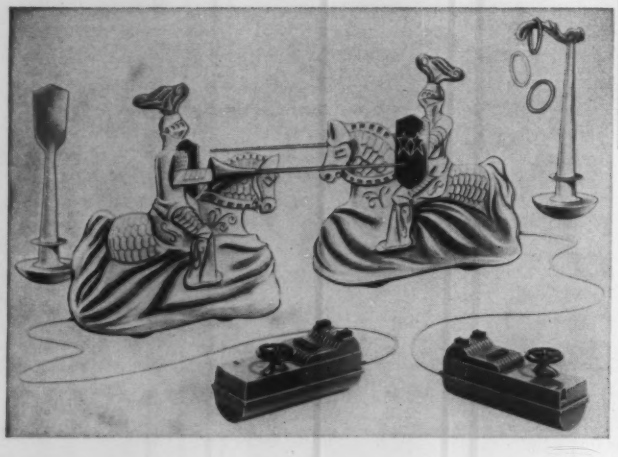
NOTHING ROLLS LIKE A BALL

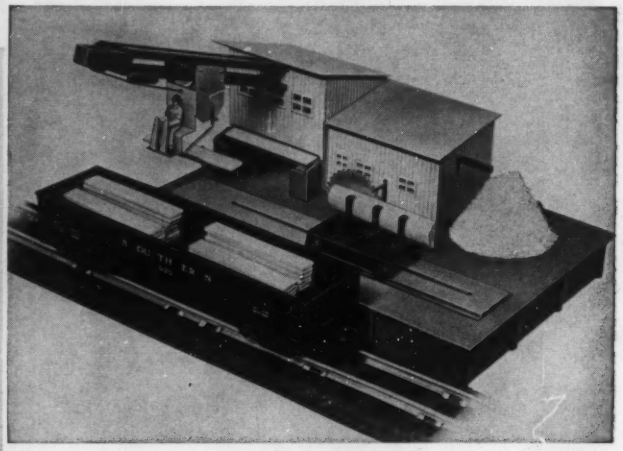
AMERICAN TOYS ROUNDUP—2





DOUBLE-DOOR BOXCAR, remote controlled, unloads aluminum barrels fed down incline.





This year's additions to American Flyer Lines, product of A. C. Gilbert Co., include:

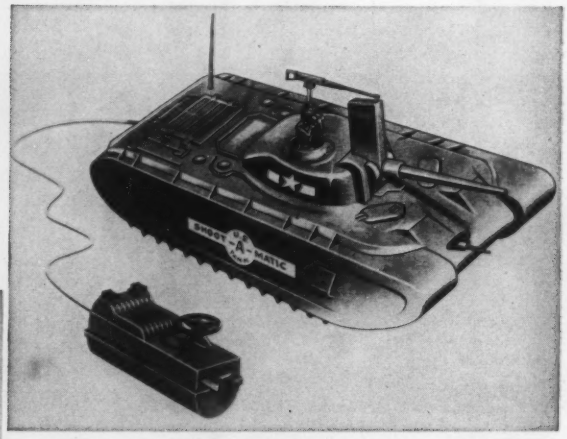
Above

SIMULATED SAWING is performed by this action accessory, remote controlled. Mill car carries log past ripping blade. Finished lumber emerges from shed, is conveyed by boom and loaded into waiting car.

Left

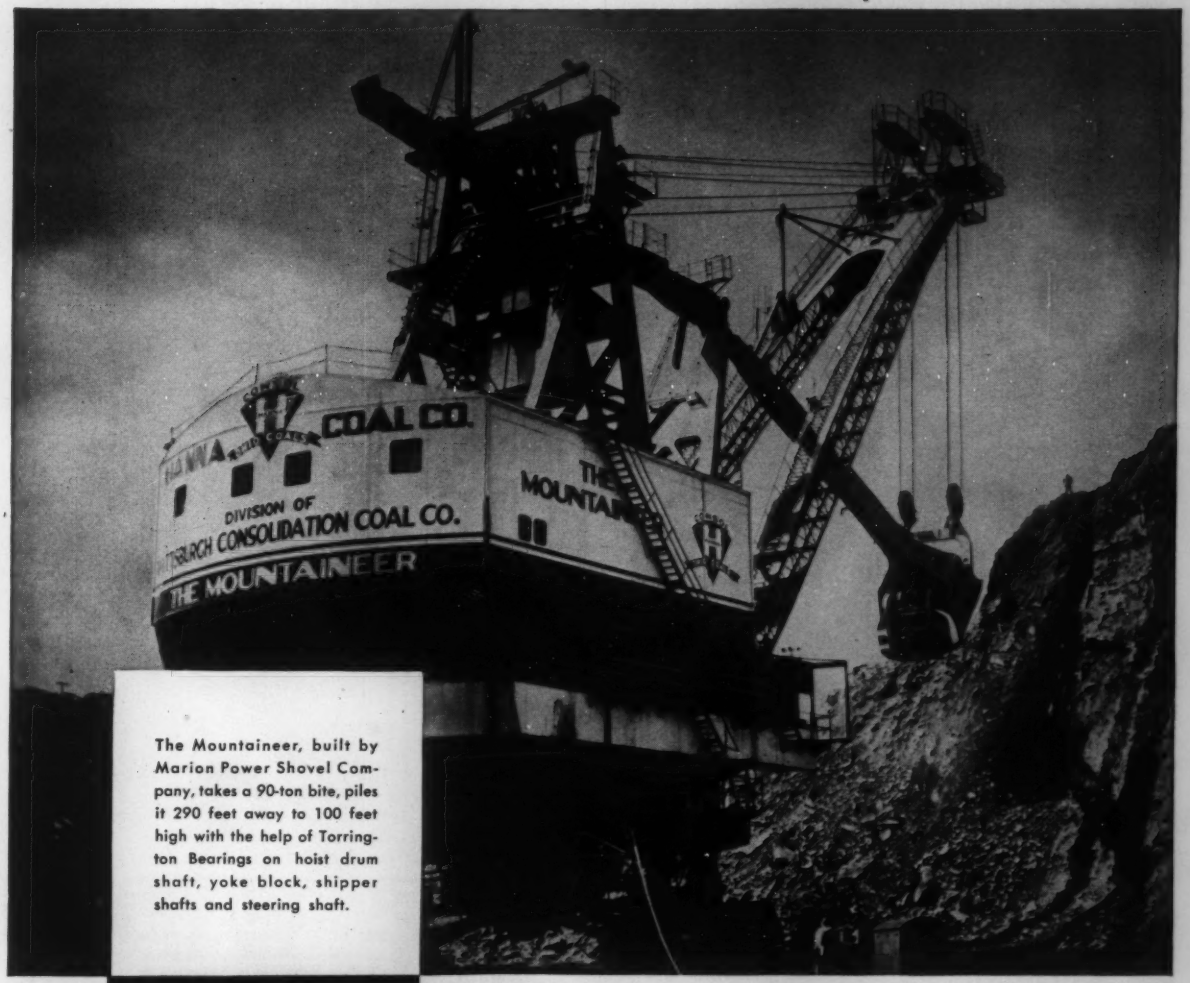
ROCKET LAUNCHER CAR, converted from conventional flat type, carries "rocket" stowed in a clip or in "ready" position atop plunger pedestal. Rocket can be "fired" while train is in motion.

Another Gilbert train item is an illuminated caboose with trainman on rear platform who emerges when train is stopped.

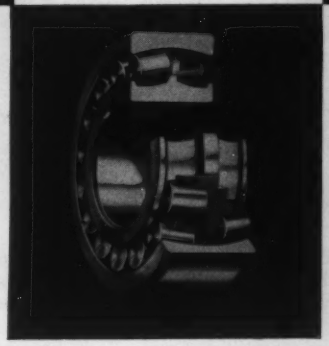


FIRE AND MOVEMENT are both controlled from a distance in this plastic tank, 8½ by 4¾ by 4¾ in., made by General Molds & Plastics Corp. Two flashlight batteries in hand-held control case power motor which drives rubber treads. Case controls also steer tank, fire pellets from gun.

KNIGHTS LIGHT UP when opponent's lance scores a hit. Jousting contestants, products of General Molds & Plastics Corp., are 9 by 9 by 4 in., made of plastic, motor driven, remote controlled. Lamps in plumes signal strikes.



The Mountaineer, built by Marion Power Shovel Company, takes a 90-ton bite, piles it 290 feet away to 100 feet high with the help of Torrington Bearings on hoist drum shaft, yoke block, shipper shafts and steering shaft.



World's Mightiest Lift Transmitted Through Torrington Bearings

The Mountaineer, world's largest power shovel, transmits its mighty lifting power – 250 tons – through two Torrington Spherical Roller Bearings on the hoist drum shaft.

Here these bearings operate smoothly at full capacity despite shaft deflections. Four other Spherical Roller Bearings are used in the yoke block to eliminate need for precise alignment of separately bored parts. In all applications, advantages of accurate roller-to-race conformity and positive roller guidance through the integral center flange contribute to long, maintenance-free service life.

To carry thrust of helical gears on shipper shafts and of the steering screw shaft, four Torrington Roller Thrust Bearings are used in each of these assemblies.

Not only in power shovels, but in all kinds of heavy-duty equipment, Torrington Bearings have proved their efficiency and long service life. *The Torrington Company*, South Bend 21, Ind.– and Torrington, Conn.

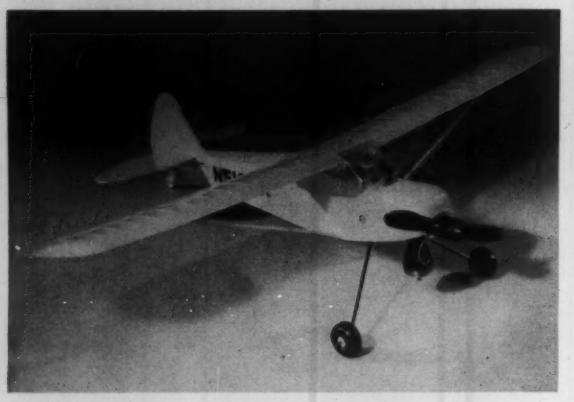
TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

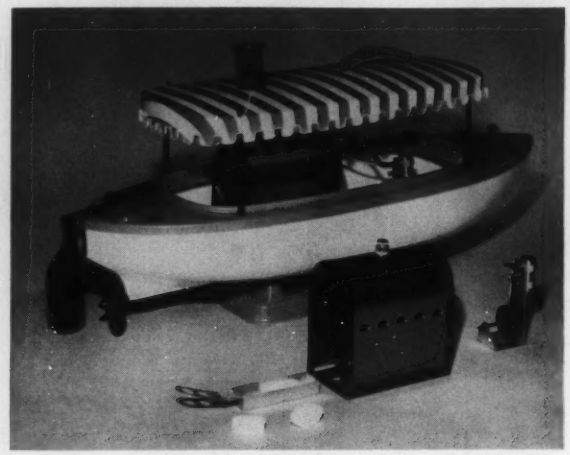
SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

Circle 410 on page 19

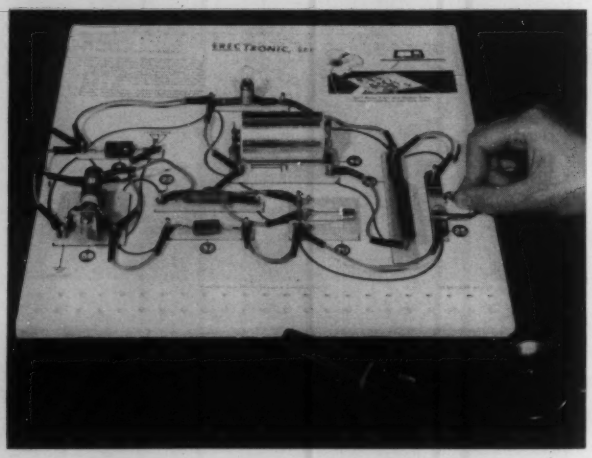
AMERICAN TOYS ROUNDUP—2



SUPER CUB, 18-in. plastic model of Piper original, is completely preassembled product of L. M. Cox Mfg. Co. Powered with single cylinder engine of 0.049 cu in. displacement, Super Cub is "piloted" with hand-held reel that carries nylon fishing line. Cox Co. also offers "trainer" plane, built to bear up under accidents, and advanced models, one with hollow, aluminum wings.



REAL STEAM powers this 18-in. plastic boat, Jungle Princess, by Atwood Motors. Fuel pellets burned under boiler heat 1/3 cup of water. Steam drives single-cylinder engine equipped with flywheel. Engine and boiler, fitted with pulley, can also be used as stationary unit to drive assemblies made with construction sets.



PEG-BOARD RADIOS are built over patterns supplied with Erectronic set No. T-150, a product of Science Electronics, Inc. Templates fit over board, show locations of components and wire plan. Pins on components fit through pattern into holes. Basic set makes any of 9 radios, each powered by 1½-v flashlight battery. Additional kits have solar battery, transistor booster.

COMPONENTS ASSORTMENTS, Master set shown, enable budding engineers to build variety of electrical devices, gadgets. Sets and instructions offered by Electric Game Co. make burglar alarms, buzzing "ray" gun, short-wave code key, bike horn.

Adhesive for Polyethylene Bonds Plastic to Rubber, Metals

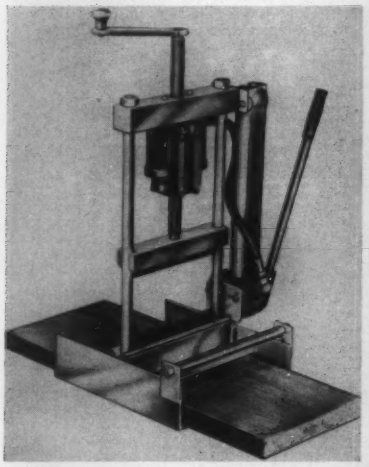
NEW YORK, N. Y.—An adhesive that resist a pull of nearly 1000 psi has been developed by Bell Telephone Lab. for bonding polyethylene to rubber, brass, or brass-plated metals. Bell will use the new product to bond insulators to conductors in telephone cable. Another significant use will be the bonding of linings to tanks. Many other uses are expected, however, since over 550 million lb of polyethylene were produced last year, and industry officials predict it will become the first billion-pound-a-year plastic—possibly by 1960.

The new process makes use of a product known commercially as Hydropol, manufactured by Phillips Petroleum Co. Various materials are added to the substance to make it capable of vulcanization.

A layer of bonding agent 0.002 to 0.003 in. thick is desirable for proper adhesion. The agent may be made up in solution and sprayed,

brushed, or dipped to provide the desired layer; or a thin sheet of the adhesive can be fabricated and inserted between the materials to be bonded.

Bonding is accomplished at temperatures ranging from 250 to 350 F and pressures of around 100 psi. Peel strength up to 100 lb per in. and tensile strength of 1000 psi are readily achieved, according to Bell.



HYDRAULIC STONE CUTTER cuts cleanly and 75 per cent faster than nonhydraulic counterpart. In the cutter, manufactured by Owatonna Tool Co., a 17½-ton ram forces two steel blades through the material. The ram is powered by a 10,000-psi pump mounted on the frame. Cutter weighs 110 lb; takes material, including granite, brick, and clay tile, up to 8½ x 10 in.

Numerical Data Programs Resistance Welding Operation

SCHENECTADY, N. Y. — A resistance welding machine, that is automatically programmed, welds tabs and cylindrical liners for jet engines. Result of applying General Electric numerical positioning and resistance welding controls to a National Electric welding machine, the unit automatically positions and welds according to numerical data on a punched paper tape. It has reduced assembly

(*Please turn to Page 22*)

DIRECTLY APPLY VARIABLE SPEEDS WITH LEWELLEN PULLEYS

Curlator Corp., builders of paper and textile machinery, variably power their Rando Feeder and Webber, using both the Lewellen Variable Pulley and the Lewellen Combination Pulleys.

Lewellen Pulleys mount at motor and machine shafts—directly connect—variably power the equipment.

Handwheel provides infinitely adjustable operating speeds.

Lewellen Pulleys, applied singly or in pairs, offer wide selection of operating speeds and center distances, in ratings to 15 h.p.

Lewellen Pulleys are versatile power components—perform smoothly and dependably—operate in any position—require no supporting brackets—impose no thrust loads on motor or machine shafts—include convenient controls and accessories.

WRITE FOR CATALOG NO. 60B

LEWELLEN MANUFACTURING CO., COLUMBUS, IND.

Distributors in All Industrial Areas • In Canada—Peerless Engineering Sales Ltd., Toronto-Montreal

Circle 411 on page 19

Consumer approach to design problem revealed...

by this Fafnir-equipped Carrier WEATHERMAKER

Typical Carrier Residential Weathermaker Installation

Just a glance at this *Residential Weathermaker* will show you how Carrier designers have catered to the interests of the consumer. The Fafnir super-quiet, permanently-lubricated pillow block circled above is a case in point. Installed on condenser units and fan, these Fafnir rubber-cushioned units eliminate a troublesome servicing problem and operate whisper-quiet. There are six of them on this *Weathermaker*.

By careful study and research into the requirements of residential heating and air-conditioning, Fafnir has developed a line of ball bearings and ball bearing units best suited to residential service. Consequently these units are contributing much towards the consumer acceptance of air-conditioning. Here is a typical example of the Fafnir "attitude and aptitude" . . . a way of looking at bearing problems from the manufacturer's viewpoint and an ability to supply the right bearing for the specific application. Perhaps they represent your means of solving a bearing problem effectively and economically. Consult your Fafnir Bearing Specialist, The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

FAFNIR RPB BALL BEARING UNIT

. . . one of a line of air-conditioning ball bearings and ball bearing units. Features include wide inner ring ball bearings with self-locking collar (easiest of all to install) super-quiet bearing construction, Fafnir Plya-Seals (contact-type), plus electric-current-conducting rubber grommets. Write for bulletin.

Circle 412 on page 19

Reader Information Service

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USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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OCT. 31, 1957

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414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
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417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
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402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
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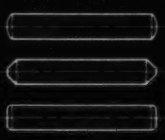
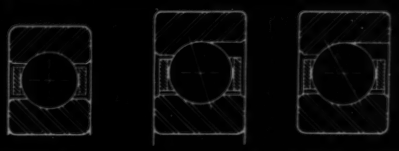


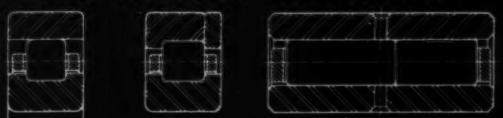
Spherical, conical or flat-end types

RADIAL BALL BEARINGS



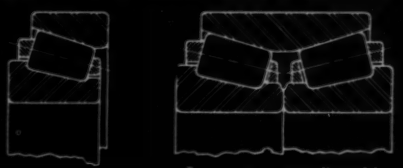
Conrad design, types LC, HC and BLC | Maximum capacity design, types HM, BLM | Angular contact design, types HA, BLA

RADIAL ROLLER BEARINGS



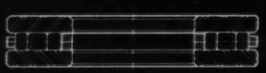
Lipped inner, straight outer race types RN, RX and RNW | Lipped inner, one lip outer, side ring type RP | Straight inner, straight outer, mill type RM

TAPER ROLLER BEARINGS

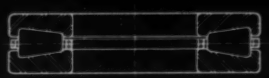


Single row type TS | Two row, non-adjustable type TNA

THRUST ROLLER BEARINGS

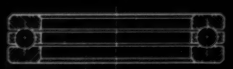


Straight roller, flat races, type RT

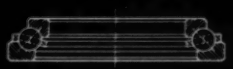


Conical roller type RTC

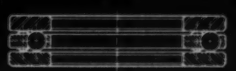
THRUST BALL BEARINGS



Grooved race type BT



Angular contact type BTA



Flat race type BTE

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(*Continued from Page* 15)
and weld time 85 per cent.

Numerical information on the tape positions the liner, selects three values of weld current and two values of weld time; also, indicates proper times for cleaning electrodes, making sample welds, and inspecting welds.

Red Moon

Appraisal of reports of first satellite, at press time, shows achievement, conflicts in statements.

Altitude at Sputnik's highest point is 560 miles according to Soviet announcement. Average altitude, however, is placed at 400 miles in statement made by Dr. John P. Hagen, director of the U.S. satellite program.

Appearance of the satellite should make it visible in low sun at distances of over 600 miles. Mirror-like finish would make it comparable to stars of from four to nine magnitude.

Cameras can be used to gather information even after batteries in satellite fail, says Dr. Whipple, Director of the Smithsonian Astrophysical Observatory. The moon-watch camera at Pasadena, Calif., will be able to take pictures revealing the density of air at high altitude and leading to more accurate computations of the earth's shape. Dr. J. Allen Hynek, Associate Director of Smithsonian Observatory said, "The Russians had none of our giant $100,000 telescope cameras, although they offered to buy ten of them this past summer, with which to photograph the artificial moon for scientific purposes."

Equipment inside the first satellite, although not mentioned in the first official Soviet announcement, was said by Dr. A. A. Blagonravov, Soviet scientist in Washington, to include a "big battery" for a powerful transmitter. When, however, Soviet experts said satellites were able to carry instruments to report on speed, temperature, and other details, they did not exclude the present satellite. Despite a further statement by Soviet scientists that the artificial moon contains radio beacons but no scientific instruments, Prof. V. Fessenkov, a member of the Soviet Academy of Science, reported the artificial moon is fitted with equipment to photograph the earth "in one part." Dr. Blagonravov said the satellite was also measuring temperature in space. He later said the satellite was filled with dry gas, presumably to insure the instruments against effects of moisture.

Future of the satellite, according to Dr. Blagonravov, is a second satellite to be launched "in the nearest future." Moscow newspapers have told readers to watch for "something special" on Nov. 7 indicating developments more startling than the satellite are in process. From Barcelona, Spain, the American delegation reports the Soviets already testing "space volunteers" from their armed forces for possible flights into space.

Life of the first man-made "moon," according to Dr. Homer Newell, a top project vanguard scientist, depends first upon determination of the orbit. Although the Russians report the satellite planned for a minimum life of two weeks, current estimates range from one month to an indefinite period. Sooner or later, said Dr. Blagonravov, the sphere will presumably be punctured by one of the fragments of material drifting about in the solar system.

Orbit of the little "moon" is reported by a Soviet broadcast to be at a 65-degree angle with the equator. U. S. observers estimate it to be only slightly elliptical. By tracing backwards on the little moon's radio signals, the Naval Research Laboratory calculated that it was launched in a northeasterly direction from a point north of the Caspian Sea at approximately 5 p.m., EDT, on Friday, Oct. 4.

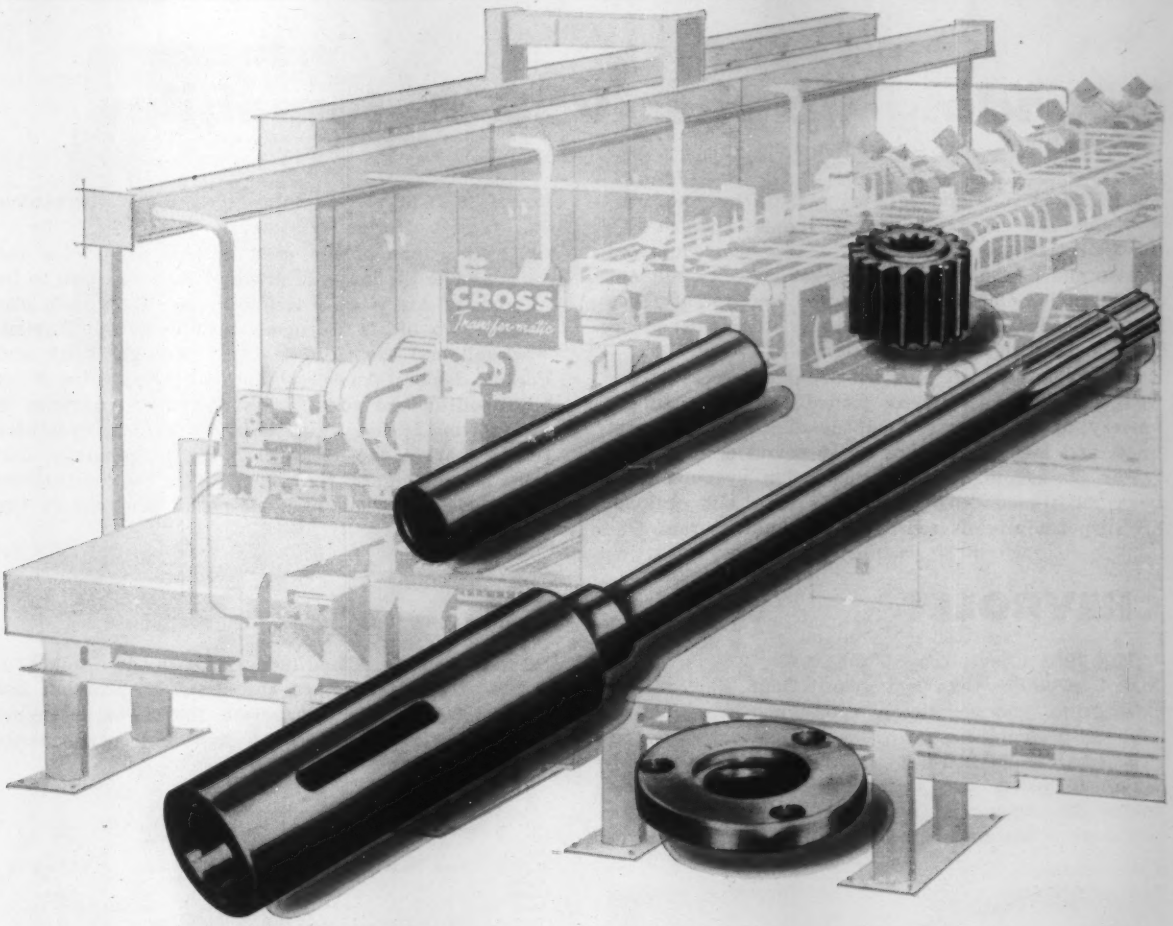
Propellant has been subject of conjecture. American scientists have noted that much heavier weight reported for Russian satellite, compared with 20-lb moon U.S. plans to launch next spring, indicates the Reds have either developed a much more efficient rocket or a more powerful fuel than the U.S. is known to have. The only way to get needed thrust without weight penalty would be for fuel to deliver five or six times as much for the same weight.

Radio transmitters, according to Soviet broadcast, were designed to work without interruption on 20.005 and 40.002 megacycles. Signals last 0.3 sec and pause for an equal length of time. The signals of one frequency are sent during the pauses in the signals of the other frequency. Reports that the satellite was transmitting code information, in addition to its regular tracking signals, came from Dr. John W. Townsend of the Naval Research Laboratory and Dr. Henry L. Richter, Jr. of the California Institute of Technology. Dr. Whipple said, "Scientists have determined the man-made moon is sending information about the temperature in the upper atmosphere." The scientist and other Americans at a recent Washington conference were promised the coded information would be made public after it had been assimilated. Power of the moon's radio has been estimated at 1 watt. The Soviet tracking system is based on the Doppler principle.

Size of the satellite is reported as 58 cm (22.835 in.) and 83.6 kg (184.306 lb). In answer to speculation over astonishing mass, Soviet scientists reiterated that Russian satellite does indeed weigh 184 lb.

Speed of Sputnik, as first measured by RCA Communications, was 4.92 mps or 17,712 mph. This was based on frequency shift during a six-minute period. Soviet broadcast announced Sputnik at start circled earth each 96.2 min.

Vehicle for launching Sputnik has been described by Prof. Y. A. Pobedonostsev as consisting of three stages. The first worked for one to two minutes, accelerated vehicle to 4340 to 4650 mph. Second stage boosted speed to 11,160 to 12,400 mph, and third stage boosted speed to about 18,000 mph and then released satellite.



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Circle 414 on page 19

Rounding Up the 1958 Automobiles

APPEARANCE and comfort rather than performance are emphasized by most manufacturers as the 1958 cars are introduced. Engines have increased in size and horsepower in a number of cases, but not on the scale of previous years. One manufacturer has actually reduced horsepower on one of its most popular models to improve fuel economy.

Styling is still affected by popular success of the wedge shape, with flared, finned fenders getting a variety of treatments. Dual headlights, lower roof lines, and less chrome are fairly common.

For passenger comfort, suspension systems have been redesigned on a number of cars, and optional air suspension is offered by most manufacturers. One exception, Chrysler, retains torsion-bar suspension and will not offer an air system.

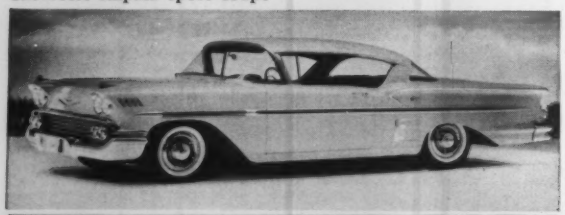
Certainly one of the most notable events for the year will be the increase in small economy cars to be offered by American manufacturers. G. M. will distribute two of its European-built cars, the English Vauxhall and the German Opel, through Buick and Pontiac dealers. American Motors continues the Nash Metropolitan and adds its new Rambler-American to the growing roster. Studebaker-Packard is reportedly set to market the 17-hp German Goggomobile, and Ford has announced that it will enter the competition when sales of small cars gain five per cent of the total market.

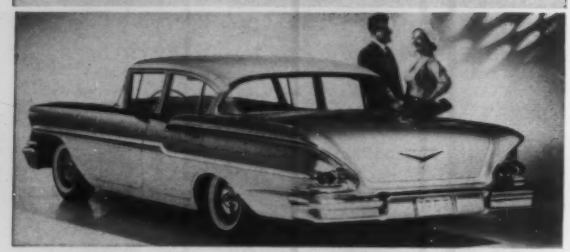
CHEVROLET

The 1958 Chevrolet is 9 in. longer, 2½ in. lower, and 4 in. wider than last year. Dual headlights, a new grille, and completely redesigned rear fenders and tail assembly round out a major styling change.

A total of 14 body styles in three series are offered, including five station wagons. Bel Air remains the top series and adds a luxury sport coupe and convertible under the Impala nameplate. Biscayne and Del Ray designate the middle and bottom range respectively.

Chevrolet Impala sport coupe





Chevrolet Biscayne four-door sedan

Mechanical changes for 1958 include a new engine, new frame, and optional air suspension.

The new Turbo-Thrust engine, optional on all models, displaces 348 cu in. compared to 283 cu in. for Chevrolet's biggest engine in 1957. It was designed primarily around a new combustion chamber which is contained entirely in the block rather than extending into a domed indentation in the head. With 3 two-barrel carburetors, the new V-8 turns out 280 hp at 4800 rpm. In comparison, the 283 cu in. engine equipped with fuel injection and high performance cams is rated at 290 hp at 6200 rpm.

Engine Specifications

Type	In line	OHV, Vee	OHV, Vee
No. cyls.	6	8	8
Bore & Stroke (in.)	3.56 x 3.94	3.87 x 3.00	4.12 x 3.25
Displ. (cu in.)	235.5	283	348
Comp. ratio	8.25 to 1	8.5 to 1*	9.5 to 1
Bhp, max	145 @ 4200	185 @ 4600†	250 @ 4400‡
Torque, max (lb-ft)	215 @ 2400	215 @ 2400§	355 @ 2800**

*9.5 to 1 with four-barrel carburetor or fuel injection.
†Horsepower ranges to 290 at 6200 depending on carburetion.
§Torque ranges to 290 at 4400 depending on carburetion.
‡Horsepower ranges to 280 at 4800 depending on carburetion.
**Torque ranges to 355 at 3200 depending on carburetion.

Size and Weight

	4-dr. Sedans	Hardtop Coupes	Convertibles
Wheelbase (in.)	117.5	117.5	117.5
Length (in.)	209.1	209.1	209.1
Width (in.)	77.7	77.7	77.7
Height (in., loaded)	57.1	55.7	55.8
Weight (lb)	3600*	3600*	3600*

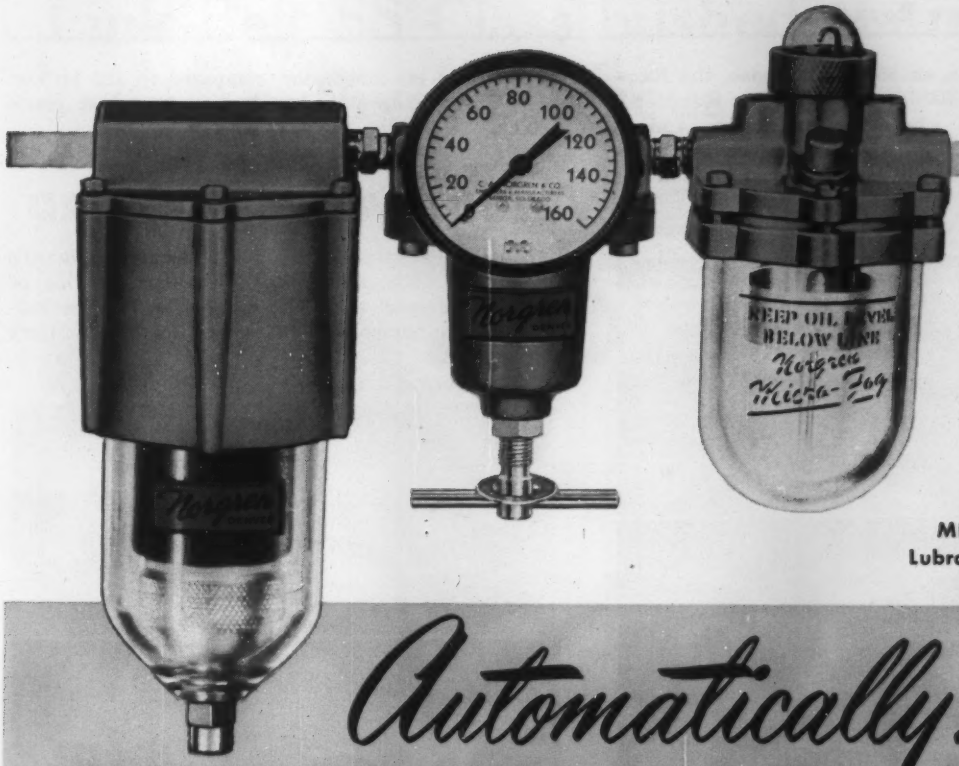
*Approximate

A redesigned suspension system employs coil springs at both front and rear wheels. Body dip during starting and stopping is said to be virtually eliminated. "Level Air" suspension which automatically adjusts vehicle height through air-spring leveling valves is offered as an option on all models.

RAMBLER

American Motors has dropped the Nash and Hudson brand names for 1958, offering its entire line under the Rambler nameplate. Restyling of the line has been in keeping with the company's trend toward "small and compact cars."

The new line-up consists of the imported, English-



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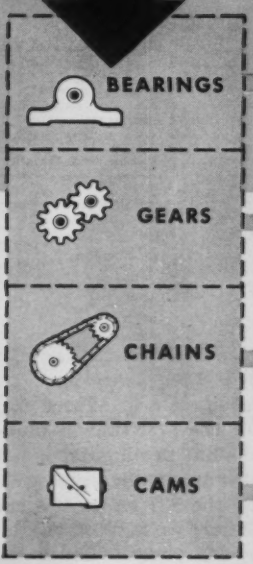

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- Only one Norgren MICRO-FOG Lubro-Control Unit is required to completely lubricate a complex machine.

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Circle 415 on page 19

built Metropolitan on an 85-in. wheelbase, the Rambler American on a 100-in. wheelbase, the Rambler 6 and V-8 on a 108-in. wheelbase, and the top Ambassador series on a 117-in. wheelbase. The new, 100-in. Rambler American will be introduced later in the year and revives the smaller body shell that was discontinued three years ago.

Rambler Cross-Country station wagon

Ambassador four-door hardtop sedan

Engine Specifications

	6-Cylinder	Rebel V-8	Ambassador V-8
Type	In-line	OHV, Vee	OHV, Vee
No. cyls.	6	8	8
Bore & Stroke (in.)	3.12 x 4.25	3.5 x 3.25	4.00 x 3.25
Displ. (cu in.)	195.6	250	327
Comp. ratio	8.7 to 1	8.7 to 1	9.7 to 1
Bhp, max	127 @ 4200 138 @ 4500*	215 @ 4900	270 @ 4700
Torque, max (lb-ft)	180 @ 1600 185 @ 1800*	260 @ 2500	360 @ 2600

*Optional twin-throat carburetor.

Size and Weight

	Rambler	Ambassador
Wheelbase (in.)	108	117
Length (in.)	191.1	200.1
Width (in.)	71.25	71.25
Height (in.)	58	58
Weight (lb; unofficial)	2925; 3230*	3340

*V-8 models

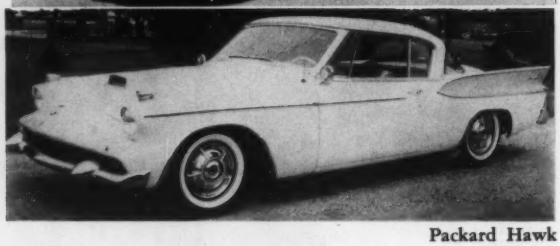
The Ambassador is offered in five body styles including, for the first time, a four-door station wagon. Horizontal dual headlights, a new grille, and finned rear fenders are major styling changes. The series is powered by the 327 cu in. V-8 engine, developing 270 hp. Four-barrel carburetor is standard equipment.

The six and eight-cylinder Rambler series is offered in 11 body styles. Overall dimensions are exactly the same as last year. Station wagon models again feature the familiar notched roof with chrome travel rack and roll-down rear windows. Performance of both the six-cylinder and V-8 engines has been improved over 1957. The six is rated at 138 hp with special carburetor, compared to 125 hp last year. The V-8 develops 215 hp; up from last year's 190 hp.

STUDEBAKER-PACKARD

The new Packard Hawk joins Studebaker-Packard's line-up for 1958, adding to the company's line of family-sized sport cars. The new model has the low-profile, high-horsepower characteristics of the Hawk series; is readily distinguished by a continental tire motif and entirely original front styling. Two other new models—two-door hardtops in the President and Commander series—will be introduced later in the year. Altogether, the line totals 14 body styles, including new editions of the Champion Scotsman series. Styling features for 1958 include lower silhouette, dual

Studebaker President four-door sedan



Packard Hawk

Engine Specifications

	Champion Series Silver Hawk	Commander Series
Type	L-head, In-line	OHV, Vee
No. cyls.	6	8
Bore & Stroke (in.)	3.00 x 4.37	3.56 x 3.25
Displ. (cu in.)	185.6	259.2
Comp. ratio	7.8 to 1	8.3 to 1
Bhp, max	101 @ 4400	180 @ 4500*
Torque, max (lb-ft)	152 @ 1800	260 @ 2800

*195 @ 4500 with optional four-barrel carburetor.

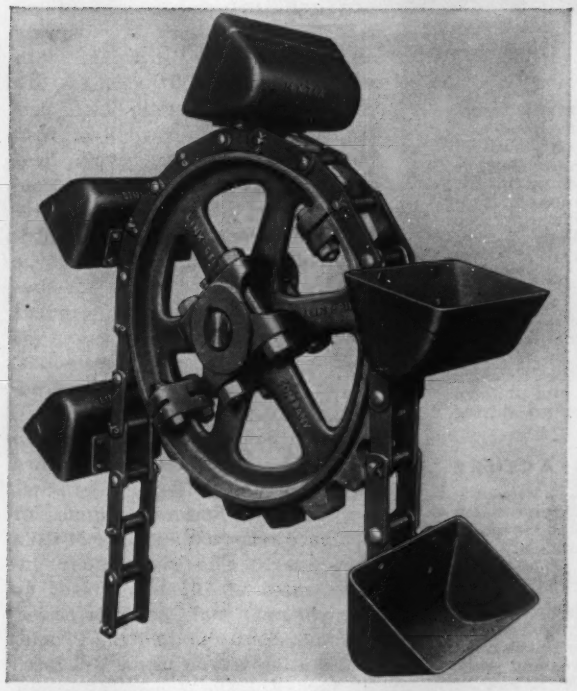
	President Silver Hawk V-8	Packard Hawk Golden Hawk
Type	OHV, Vee	OHV, Vee
No. cyls.	8	8
Bore & Stroke (in.)	3.56 x 3.62	3.56 x 3.62
Displ. (cu in.)	289	289
Comp. ratio	8.3 to 1	7.8 to 1
Bhp, max	210; 225*	275
Torque, max (lb-ft)	300 @ 2800; 305 @ 3000*	333 @ 3200

*With 4-barrel carburetor standard on President series.

Size

	Commander, Champion Series	President	Hawk Series
Wheelbase (in.)	116.5	120.5	120.5
Length (in.)	202.4	206.2	203.9
Width (in.)	75.8	75.8	71.3
Height (in.)	58	57.5	54.7

Link-Belt SS Class bushed chain outlives previous chain 4 times



LONG, TROUBLE-FREE SERVICE of SS-111 chain (above) proves that it pays to select the right chain for a specific job from Link-Belt's complete line. It also proves that there's no need to pay a premium for costly special alloy steel chains.

Outstanding record established in severe, abrasive elevator service

This remarkable service record set by a Link-Belt SS-111 bushed chain (left) proves that often there's no need to go to excessively costly special alloy cast chains to get long life. Used at an Indianapolis (Ind.) fertilizer plant, this chain handled an average of 75,000 to 80,000 tons of fertilizer before requiring replacement. The previous type of chain handled only 18,000 tons and required four times as much maintenance.

Designed for abrasive jobs

Link-Belt SS-111 bushed chain offers large joint bearing surfaces for greater wear resistance and trouble-free service in heavy-duty conveying and elevating. Sidebars of selected bar steel are accurately formed and machined for tight press fit of pins and bushings. The latter are made from tough, hardened steel and locked against rotation in sidebars.

These straight steel sidebars with hardened steel pins and bushings provide needed strength to prevent distortion under continuous heavy loads. Smooth, tough surfaces repel gritty materials, prevent packing in critical joints, resist abrasion and corrosion.

Many sizes of these heavy-duty chains are interchangeable with Link-Belt combination chains. And a wide range of attachments makes them adaptable to specific conveying and elevating requirements.

18 million tons, 26 years later... SS-856 chain still serviceable

Sets record in cement mill elevator service

The more than quarter-century of continuous handling of raw materials at a Pennsylvania cement mill illustrates the long-wearing durability of Link-Belt SS-856 elevator chain. This amazing service record under extremely tough conditions proves that it pays to pick the right chain from Link-Belt's complete line.

Link-Belt SS-856 chain is made of high carbon steel sidebars with nickel alloy pins and bushings. Hardened sidebars give additional strength plus greater resistance to wear and pitch hole distortion. In addition, accurately machined pitch holes assure proper pitch and tight press fit of mating parts —extend chain life. The hard, smooth surfaces of steel joints repel gritty materials . . . resist abrasion.

Link-Belt elevator chains are available with ultimate strengths up to 200,000 lbs.

Link-Belt SS-102½ bushed chain extends life of stone elevator

Several years ago an eastern stone quarry installed a main bucket elevator to handle 200 tons per hour of minus 2¼-in. mixed stone. Service life of the original two-strand elevator chain was found inadequate. After several shutdowns, it was replaced with Link-Belt SS-102½ chain with K-5 attachments at every third link.

This long-life, wear-resistant chain is now in its fourth year of uninterrupted operation. It has carried close to 350,000 tons as compared to 60,000 tons which was considered normal life for the previous chain.

Recent inspection of the SS-102½ chain reveals that it is good for another long stretch of service. Elimination of shutdowns and replacements more than justified the slight difference in cost between this and the original chain.

STONE ELEVATOR has buckets at every third link. Centers are 65 feet, with elevator inclined 75 degrees from the grade. Chain speed is 280 feet per minute.

HEADQUARTERS for chains, sprockets and other Link-Belt conveying and mechanical power transmission products is your nearby Link-Belt Office.

LINK-BELT

CHAINS AND SPROCKETS

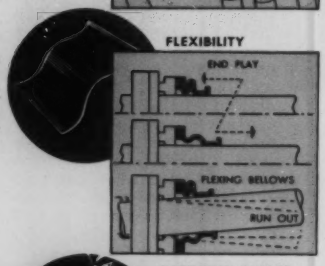
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,294-A

JOHN CRANE

Shaft Seal Design With A Purpose!

POSITIVE DRIVE

This gives long seal life. Drive is transmitted through the driving band and washer driving notch which absorb all breakout and running torque. Damaging stresses on the bellows or flexible sealing member are eliminated. Slippage is also eliminated, thus protecting shaft or sleeve against galling.



FLEXIBILITY

Axial and radial misalignment problems are eliminated. Self-adjusting bellows or sealing head automatically compensates for shaft end play or run out. Minimum spring pressure is required for axial shaft movement and uniform spring pressure is maintained during radial shaft movement.

PRECISION MANUFACTURE

Leakproof performance is assured. Washer and seat surfaces are precision lapped to a perfect mate under a patented "John Crane" process.

A SEAL FOR EVERY SERVICE

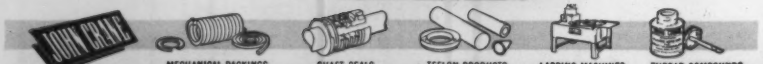
All "John Crane" Seals are constructed to the particular service requirements . . . from hot or cold water to the most destructive acids, corrosives and gases . . . temperatures up to 1000°F. . . . pressures to 1200 psi. They can be furnished in types and sizes to meet practically any mechanical or dimensional condition.

Request Bulletin S-204-2. Containing full information on "John Crane" engineered shaft seals.

GET COMPLETE DETAILS

Crane Packing Co., 6425 Oakton Street, Morton Grove, Ill. (Chicago Suburb)

In Canada: Crane Packing Co., Ltd., Hamilton, Ont.



CRANE PACKING COMPANY

headlights, and canted rear fins.

A new one-piece driveshaft permitted lowering of the rear tunnel and pan, reducing height of all models about 3 in. New spring and shock rates, together with variable rate coil springs are claimed to give better load performance under a variety of road conditions. Longer rear leaf springs are set slightly back from center over the rear axle to prevent the car from dipping on sudden starts or stops. A link type front stabilizer, replacing the previous linkless bar, is said to cut roll and sway in cornering and afford better stability in cross winds.

Fin-cooled brakes and twin traction differential are again featured on the new models, with 14-in wheels being offered as standard equipment on all V-8s.

Studebaker-Packard's engines for 1958 are relatively unchanged from last year. The six-cylinder engine, rated at 101 hp, is used on the Scotsman and Champion series. Commander series and the Provincial station wagon use a V-8 rated at 180 hp. The Sweepstakes V-8, powering the President and Hawk series, is rated at 210 hp with two-barrel carburetor, 225 hp with four-barrel carburetor, and 275 hp with supercharger.

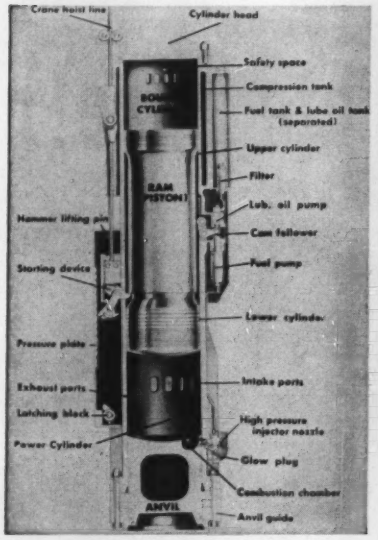
MACHINE DESIGN's roundup of the 1958 model automobiles will be continued in the November 14 issue.

Pile Hammer of Closed Design Gives More Blows Per Minute

Transforms Power Crane Into One-Man Pile Driver

CHICAGO—Use of a one-man controlled diesel pile hammer transforms any power crane economically into a pile driver, says the Link-Belt Co. A single cable to hoist the hammer into the leads in which it operates is all that is required to position it and start its operation. Three models offer range of 7500 to 30,000 ft-lb per blow.

The hammer is a self-contained, free-piston, compression-ignition



Closed-top pile hammer keeps pile in motion, prevents "setting up," and minimizes brooming.

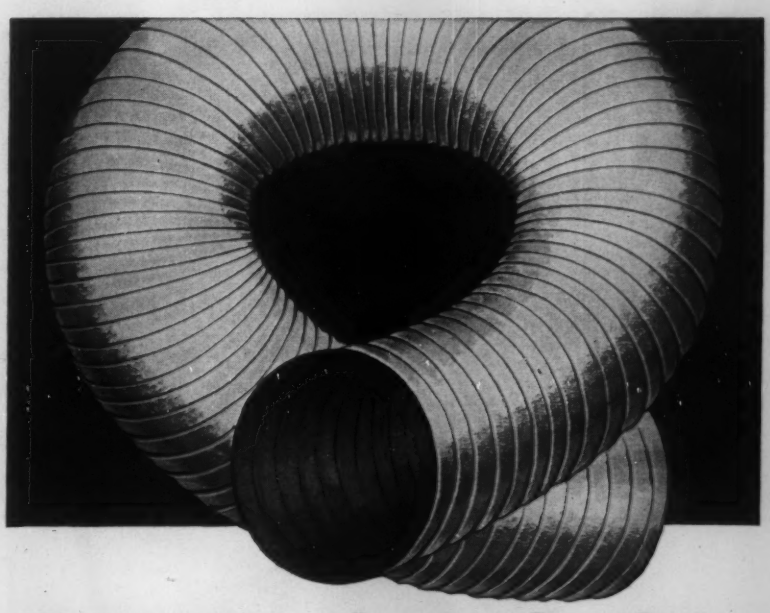
machine operating on the two-cycle principle. Energy is delivered to the pile head, through the anvil, in three stages: Preload, impact, and explosive force.

The ram is accelerated downward by gravity and the expansion of air in the compressor. Ram action forces a mixture of air and residual gases through the exhaust ports, compresses the trapped air mixture to ignition temperature and impacts. Expansion of the combustion gases drives the ram upward; it uncovers the ports allowing the gases to "blow down," then draws in fresh air through intake ports and simultaneously compresses air in the upper chamber to complete the cycle.

Unlike the conventional diesel pile hammer, the Link-Belt unit incorporates a closed cylinder top which traps and compresses air to form an "air spring." This limits upward travel of the ram, accelerates the ram downward and enables the hammer to obtain more blows per minute.

Cold nitrogen keeps refrigerator at temperature of −320 F for as long as 23 days without external power. In unit field-tested by Linde

(*Please turn to Pege* 32)



Questions about Flexflyte®

most frequently asked by design engineers

What is Flexflyte?
A lightweight, reinforced ducting made of a spring steel wire helix covered with coated fiber glass or a cotton fabric and bound with a fiber glass cord.

What are its applications?
Equipment designers will find Flexflyte ideal for applications where an unobstructed flow of air, gases, liquids, chemicals, light solids must be maintained.

How flexible is Flexflyte?
It will take tight turns at any point up to 180° without buckling. No elbows or fittings are required.

What are its temperature ranges?
From minus 120°F. to plus 650°F.

What pressures will Flexflyte handle?
Internal working pressures up to 70 psi and external working pressures up to 15 psig.

Is it flame resistant?
Flexflyte has exceptionally high flame resistance and will not support combustion.

What about Flexflyte's resistance to abrasion?
It is highly resistant to abrasion, especially when coated with FT-506 which has more than 200 times the abrasion resistance of any tubing of its type and weight.

What about installation?
Flexflyte is quickly, easily installed around corners and equipment parts by means of metal clamps. It is also available with special enlarging or reducing ends, either cylindrical, rectangular or polyhedral.

Can Flexflyte be engineered for unusual applications?
Yes. Special fabrics, coatings, connections, lengths and diameters are available. Our special Silicone Department, working with automated machinery, is prepared to meet any requirement for silicone ducting.

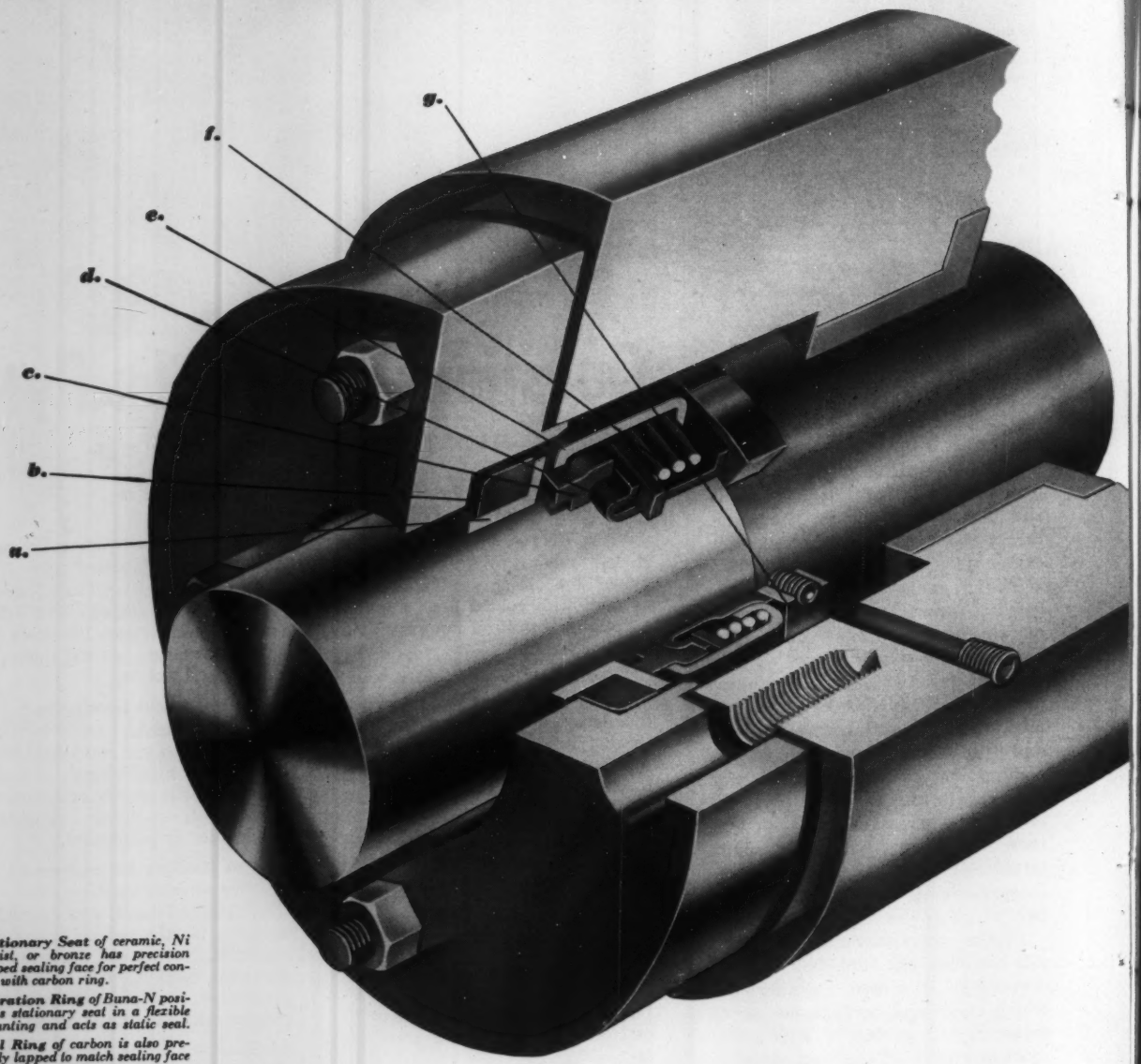
How can I make sure that Flexflyte will solve my problems?
Write us, outlining your requirements. Our engineers will be glad to put their experience to work for you. Write Dept. 180.

Flexible Tubing
CORPORATION
GUILFORD, CONNECTICUT • LOS ANGELES 64, CALIFORNIA

Circle 418 on page 19

MORE OF THE GARLOCK 2,000

No More Stuffing Box Maintenance!



***a. Stationary Seat** of ceramic, Ni Resist, or bronze has precision lapped sealing face for perfect contact with carbon ring.*

***b. Vibration Ring** of Buna-N positions stationary seat in a flexible mounting and acts as static seal.*

***c. Seal Ring** of carbon is also precisely lapped to match sealing face of stationary seat.*

***d. Roll type Bellows** permits free movement of seal ring.*

***e. Shell**, encases entire rotary unit and furnishes mechanical drive for seal ring.*

***f. Stainless Steel Spring** with load precisely calculated to face area of seal.*

***g. Stop Collar**, or shoulder, positions seal to specified operating length.*

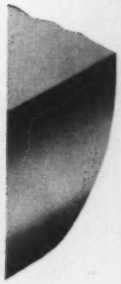
THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Specify Garlock Package Seals for Your Pump Designs

- *ELIMINATE LEAKAGE AND SHAFT WEAR*
- *REDUCE DOWNTIME*
- *CUT MAINTENANCE COSTS*

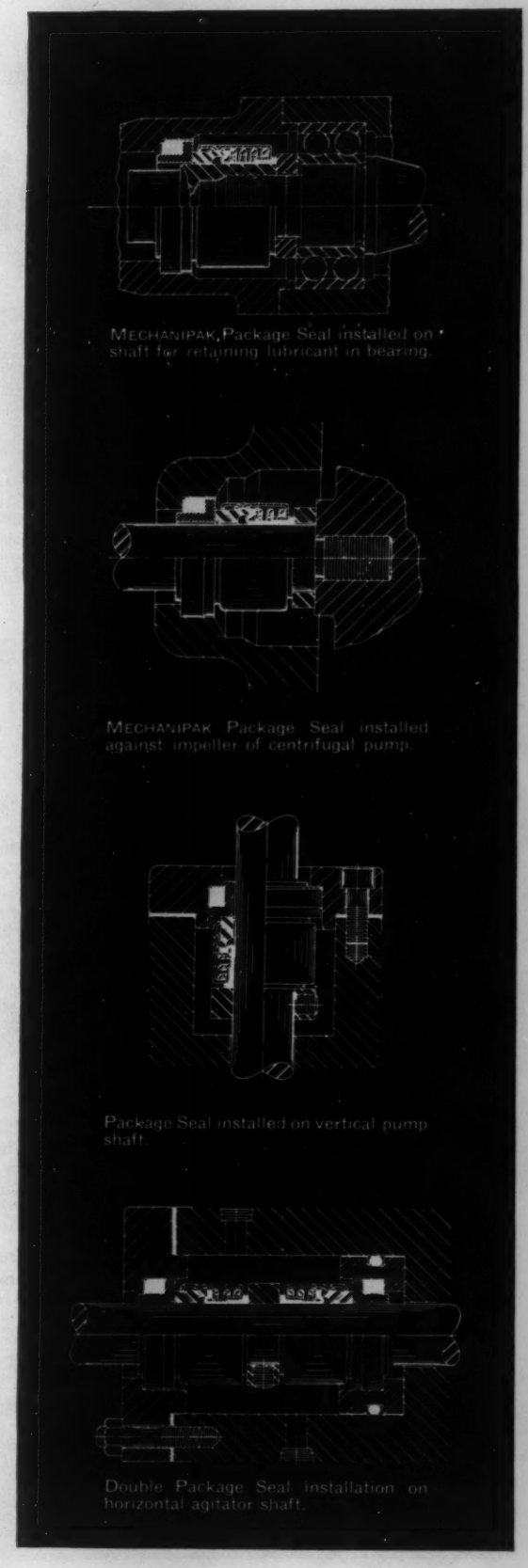


When leakage and maintenance are serious problems in the operation of the pumps you design—specify Garlock MECHANIPAK* Seals. Installation on new or existing equipment is simple. And, several designs are available to meet a variety of operating conditions: pressures to 150 psi, temperatures to 212° F., and shaft speeds to 2000 feet per minute. Sizes for shafts from ⅜" to 3" diameter for sealing against water, oils, alcohol, mild acids and solvents.

MECHANIPAK Seals are another important part of "the Garlock 2,000" . . . two thousand different styles of packings, gaskets and seals for every need. It's the only complete line . . . that's why you get unbiased recommendations from your Garlock representative. Ask him for complete data on this long-life, maintenance-free MECHANIPAK Seal. Or write for Folder AD-150.

*Registered Trade Mark

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints, Fluorocarbon Products



MECHANIPAK Package Seal installed on shaft for retaining lubricant in bearing.

MECHANIPAK Package Seal installed against impeller of centrifugal pump.

Package Seal installed on vertical pump shaft.

Double Package Seal installation on horizontal agitator shaft.

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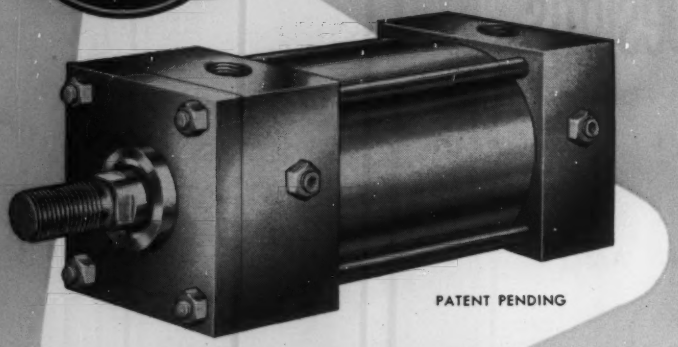
FOR AUTOMATION

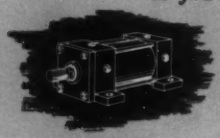
SP CYLINDERS



PATENT PENDING

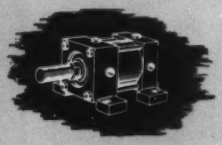
top performance–longest life

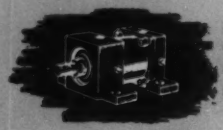
All S-P cylinders are engineered throughout for high speed, efficient operation. Piston rods are heat treated and hard chrome plated to resist scoring. Bronze cartridges with extra long bearing surfaces are easily removable for quick servicing of rod seals and wipers. End plates are rolled steel. All S-P cylinders are built to JIC standards.



S-P STANDARD AIR CYLINDERS have brass tubes to eliminate corrosion. Cushions float on O-rings for maximum cushioning. Eleven bore sizes, 1½" — 14". 21 mounting types. Readily modified for oil or water. Send for Catalog No. 110.

S-P HEAVY DUTY AIR CYLINDERS for automation and other severe applications. Double porting for extreme high speeds. Heavy wall seamless steel tube. Nine bore sizes, 1½" — 8". Five mounting types. Approved and used by two major automobile manufacturers. Send for Catalog No. 109-A.





S-P HIGH PRESSURE HYDRAULIC CYLINDERS have seamless steel tube. Special locking mechanism eliminates tie rods. Designed for 2,000 psi. Eleven models in 11 sizes. Send for Catalog No. 104.

Step up production with S-P cylinders. Representatives in principal cities. Prompt deliveries. Order catalog by number shown above. The S-P Manufacturing Corporation, 30201 Aurora Rd., Solon, Ohio. *In greater Cleveland.*

SPecify SP

SP THE S-P MANUFACTURING CORP.

SOLON, OHIO • *IN GREATER CLEVELAND*

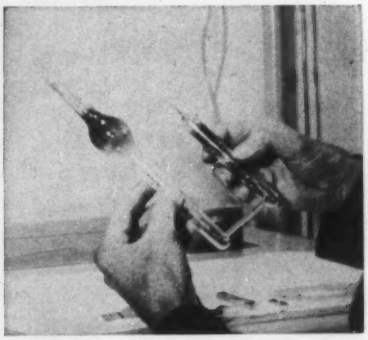
ESTABLISHED 1916 A BASSETT COMPANY

NON-ROTATING AIR AND HYDRAULIC CYLINDERS • ROTATING AIR AND HYDRAULIC CYLINDERS
POWER CHUCKS • COLLET AND DRILL PRESS CHUCKS • AIR PISTONS, VALVES, ACCESSORIES

News Roundup

(*Continued from Page 29*)

Co. Div. of Union Carbide Corp. for two years before being marketed, a single charge of nitrogen in liquid form eliminates need for outside power source. The unit weighs 115 lb when fully charged with nitrogen, and 60 lb empty. It consists of a double-walled container-within-a-container. Sides are of welded stainless steel.



SUPERACCURATE LIGHT SOURCES measure as close as fractions of millionths of an inch. First two krypton 84 isotope tubes in U. S. industry, developed by West Germany's Bureau of Standards, will be used by Sheffield Corp. as light sources of the utmost known precision. The lamps will be used in an interferometer to measure light wave fringes to accuracies of less than a millionth of an inch.

Computer Readout Prints 600-Page Book per Minute

SAN DIEGO, CALIF.—Computer readout system that records ten times faster than any similar device has been developed for Operations Research Office of Johns Hopkins Univ. Utilizing a Type C7C11 beam tube, the Stromberg Carlson Model 100 Charactron Computer Readout is capable of recording in permanent, readable form the output from an electronic computer at a rate equal to one 600-page book per minute.

Heart of the readout is a 7-in. C7C11 tube which reproduces letters and numbers 0.030 in. high. Face of the tube can accommodate 6500 characters at any one time,

Metals Matters

Large-scale chemical milling is possible in a new 60-ft tank designed to process extremely long, tapered structures for aircraft. The chemical milling process has proved valuable in producing smooth tapers on long parts, such as wing spars. Taper angle is controlled by rate of immersion into the etching solution. In the new tank—operated by the Manhattan Beach, Calif., plant of U. S. Chemical Milling Corp.—a hydraulic drive system powering the overhead hoist provides immersion speeds of 0 to 120 fpm.

• • •

Titanium ingots weighing 7200 lb, believed to be the world's largest, are being produced for the aircraft industry by Rem-Cru Titanium Inc. The new 32-in.-diam titanium ingot is the same size as a 13,000-lb steel ingot.

• • •

Largest cast aluminum assembly, consisting of four sand castings weighing over 12½ tons, was installed as part of a wing fabricating table at the Columbus plant of North American Aviation Inc. The assembled aluminum chuck measures 28 ft long, 130 in. at the widest point, and 16 in. deep. Machining tolerances at the chuck surface are maintained to within ±0.002 in. to insure that the finished part is held to within ±0.005 in.

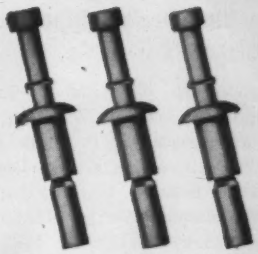
• • •

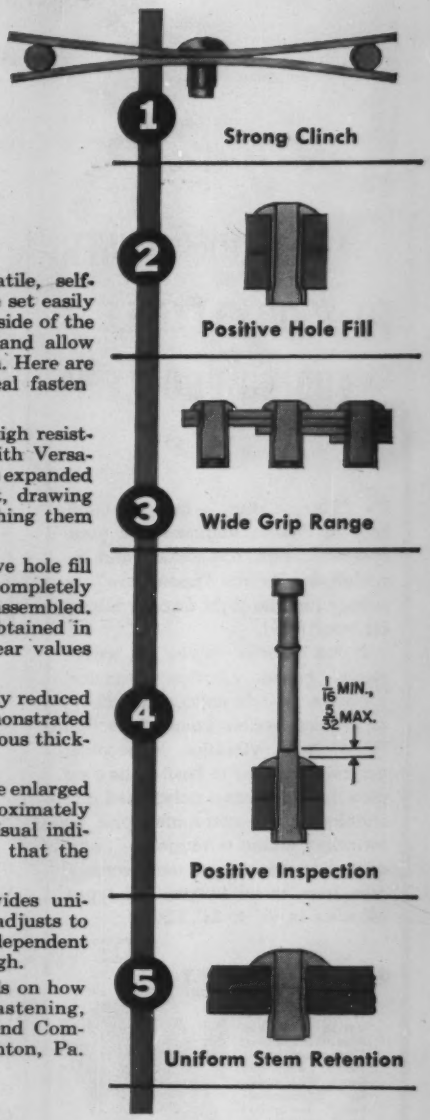
Niobium-base materials research and development will be undertaken at Rensselaer Polytechnic Institute, under contract from the Navy Bureau of Aeronautics. Possible applications of high-temperature niobium (also known as columbium) are in gas turbines and jet engines. Supply of this metal, mainly from Nigeria, has been limited. However, recently developed North American deposits suggest a potential supply greater than the combined potential supply of nickel and molybdenum.

can be filled three times in 2 seconds.

Model 100 Assembly includes the tube, electronic circuitry to operate it and to interpret and synchronize instructions from the computer,

Five reasons why Townsend Versa-rivets* give you superior fastening





Townsend Versa-rivets are versatile, self-plugging blind rivets which can be set easily and rapidly by one man from one side of the work. They save assembly time and allow greater flexibility in product design. Here are the five qualities which mean ideal fastening at lower costs:

1. Strong clinch and resulting high resistance to vibration are obtained with Versa-rivets. In setting them, the shank is expanded against the face of the back sheet, drawing the two sheets together and clinching them effectively, as shown above.

2. Versa-rivets provide a positive hole fill because the stem is drawn down to completely fill the hole in the members being assembled. Sound, strong riveted joints are obtained in holes up to .025″ oversize with shear values comparable to solid rivets.

3. Inventory problems are greatly reduced by the wide grip range as demonstrated above. A single length handles various thicknesses.

4. When the Versa-rivet is set, the enlarged section of the stem protrudes approximately 3/32″ above the rivet head, giving visual indication from one side of the work that the rivet is properly set.

5. The Versa-rivet always provides uniform strength as the stem always adjusts to fill the hole. Stem retention is independent of the hole size and is uniformly high.

If you would like complete details on how Versa-rivets can improve your fastening, write for Bulletin TL-119. Townsend Company, P.O. Box 237-E, New Brighton, Pa.

*Patents issued & pending.

Townsend
COMPANY • ESTABLISHED 1816
Sales Offices in Principal Cities
In Canada: Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario

Circle 421 on page 19

HAS THE ANSWER TO YOUR FLEXIBLE TUBING PROBLEMS

It's "Flexineering" — the technical help of Penflex engineers on your specific design, application and installation *plus* the "know how" to supply just the right flexible tubing for your need.

If you want to convey air, water, steam, gases, volatiles; granular, abrasive or light solid materials . . . or require flexible connections that "give" with vibration, expansion, contraction, come to Penflex. Its complete line of bronze, galvanized and stainless steel, corrugated and interlocked tubing is rugged . . . safe at high pressures and temperatures, free from metal fatigue. All types, all sizes in ⅛" to 24" I.D.

GET YOUR COPY

Write Pennsylvania Flexible Metallic Tubing Company, Inc. 7239 Powers Lane, Phila. 42, for "Flexineering" helpful book on tubing.

PENFLEX

TIGHT AS A PIPE BUT... FLEXIBLE

Circle 422 on page 19

digital-to-analog computers, a high-voltage supply, and a power supply for operating the electronic circuits and camera recorder.

Machine Design Appoints Assistant Editor

CLEVELAND—Bernard D. Ross has joined the staff of MACHINE DESIGN as an assistant editor. Mr. Ross received his education at Lowell Institute School, Cambridge, Mass., and Massachusetts Institute of Technology. While at MIT, where he majored in electrical engineering, he worked at both the Cyclotron and the Servo Lab. Subsequent affiliations include those of senior handbook writer at Republic Aviation; technical writer at Designers for Industry; and, most recently, technical data supervisor at the Pneumatic Div. of Thompson Products Co. Mr. Ross' assignment on MACHINE DESIGN is preparation of material for the Engineering News Roundup section.

Bernard D. Ross

Meetings

AND EXPOSITIONS

Nov. 11-15—

National Electrical Manufacturers Association. Annual Meeting to be held at the Traymore Hotel, Atlantic City, N. J. Additional information is available from NEMA headquarters, 155 E. 44th St., New York 17, N. Y.

Nov. 13-15—

American Standards Association. 39th Annual Meeting and Eighth National Conference on Standards to be held at the St. Francis Hotel, San Francisco. Additional information is available from association headquarters, 70 E. 45th St., New York 17, N. Y.

Nov. 13-16—

Society of Naval Architects and Marine Engineers 65th Annual Meeting to be held at the Waldorf-Astoria Hotel, New York. Further information is available from society headquarters, 74 Trinity Place, New York 6, N. Y.

Nov. 14-16—

American Society of Refrigerating Engineers 44th Semiannual Meeting to be held at the Shoreland Hotel, Chicago. Additional information can be obtained from society headquarters, 234 Fifth Ave., New York 1, N. Y.

Nov. 18-21—

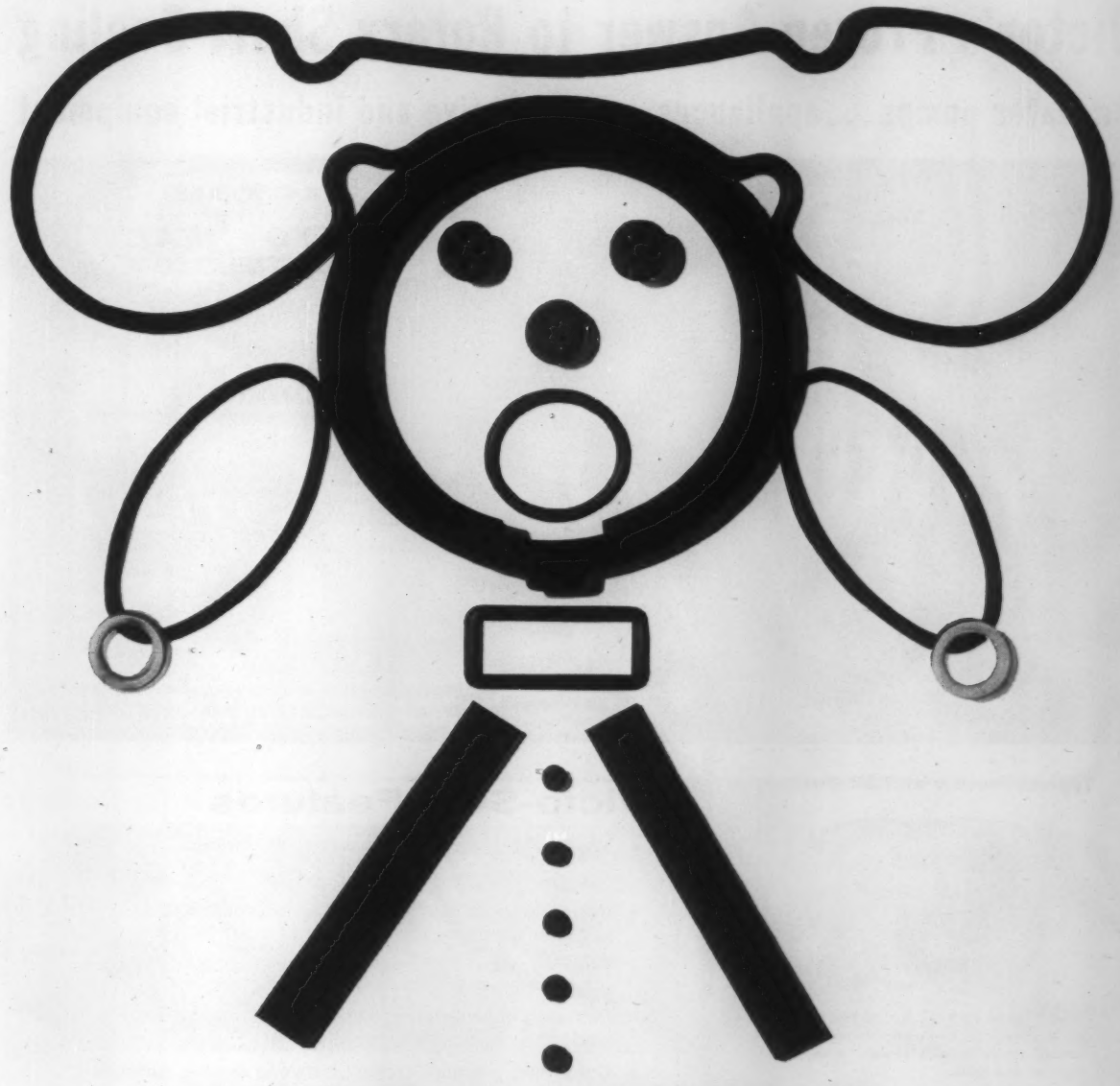
Air Conditioning and Refrigeration Institute. Tenth Air Conditioning and Refrigeration Exposition to be held at the International Amphitheatre, Chicago. Additional information can be obtained from R. H. Israel, Virginia Smelting Co., West Norfolk, Va.

Dec. 1-6—

American Society of Mechanical Engineers. Annual Meeting to be held at the Statler and Sheraton McAlpin Hotels, New York. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

Dec. 9-13—

Eastern Joint Computer Conference and Exhibit to be held at the Sheraton-Park Hotel, Washington, D. C. Sponsors are Institute of Radio Engineers, Association for Computing Machinery, and American Institute of Electrical Engineers.



ROTH molds SILICONE
PARTS AND SPONGE

Why Silicone? • Extreme serviceable temperature range—from below −100°F. to +500°F. • High resistance to compression set—maximum of 20% from −25°F. to +325°F. • Exceptional resistance to oxidation—weathering, ozone and corona.

Why ROTH? • Top Production Know-How—33 years of experience serving hundreds of manufacturers—excellent engineering and production staff. • Better Service and Delivery—Roth can meet your deadlines. • Priced Competitively—proven by hundreds of satisfied clients.

If molded rubber is a problem—
let ROTH solve it.

ROTH
RUBBER COMPANY
1860 S. 54th Ave., Chicago 50, Ill.

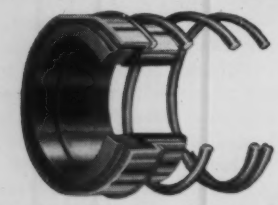
Circle 423 on page 19

Victor's Proven Answer to Rotary Shaft Sealing

On water pumps... appliances... automotive and industrial equipment

Victo-Seal Type 6 Axial Face Seal with Victoprene outside diameter. Easily installed and removed. Metal parts completely encased in Victoprene diaphragm to which seal ring is bonded.

Typical Proven VICTOR Designs



Victo-Seal Type 2 Axial Face Seal. Its efficiency in preventing leakage on rotating shafts is well known. Also seals against end plates.

Victo-Seal Type 7 End Face Seal with metal outside diameter with fully protected rubber-enclosed spring.

Victo-Seal Features

- Made with Victoprene elastomer diaphragms
- Simple, self-contained units
- Easily, economically installed on production line, in repair shops, in the field
- Positive torque lock that eliminates diaphragm fatigue, maintains constant unitary function
- Self-aligning—compensates automatically for wear, shaft movement; absorbs vibration
- Controlled pressure contact between sealing surfaces maintained by long-life compression spring
- Moderately priced
- Victor well-known quality throughout—in design, construction, materials

Send for fully descriptive literature

Literature is available through your Victor Field Engineer, or on request. Please state nature of application. Write Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill. In Canada: Victor Mfg. & Gasket Co. of Canada Limited, Victor Drive and Chester St., St. Thomas, Ont.

VICTOR

Sealing Products *Exclusively*

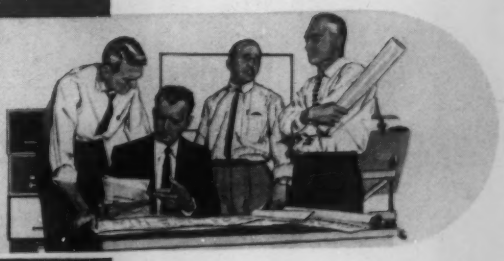
GASKETS • OIL SEALS • PACKINGS • MECHANICAL SEALS

Circle 424 on page 19

Circle 425 on page 19→

Drafting Department Heads!

Faced with increased demands for drawings and prints . . . the shortage of experienced personnel?



Look how Bruning can help you add

to your Drafting Room!

Look How Many Ways New, Modern Bruning Products Add Manpower to Your Drafting Room by Saving Man Hours of Work!

SAVE
DRAFTING
MAN HOURS

SAVE
REPRODUCTION
MAN HOURS

SAVE
FILING
MAN HOURS

Right now when you need it... add manpower to your drafting room by replacing old or inadequate equipment and materials with these modern, time-saving Bruning Products!

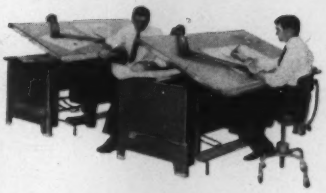
At the *drawing board*, at the *reproduction machine*, at the *files* . . . you can add manpower right now by helping your personnel turn out more work, faster and easier, with these modern, higher-production Bruning products.

See how modern Bruning drafters speed drafting up to 40% on most jobs . . . new and better tracing papers and cloths enable faster drawing and reproduction . . . improved intermediates slash re-drafting time for design changes . . . new, improved Copyflex machines provide faster and more convenient reproduction.

In the face of increased demands for drawings and prints and the shortage of experienced personnel, you couldn't choose a better time to replace old or inadequate equipment with these new, higher-production products you've been wanting. You couldn't pick a more opportune time to get management approval for new equipment expenditures.

Bruning's wide selection of drafting aids includes not only standard items, but many time-and-work savers such as dotting pens, proportional dividers, planimeters, special purpose templates, and Bruning electric erasing machines that save hours of finger-cramping manual erasing.

MODERN DRAFTING TOOLS AND SUPPLIES HELP SPEED DRAFTING



MODERN BRUNING TRACING MEDIUMS SPEED DRAWING AND REPRODUCTION

These new, improved drawing mediums are unsurpassed for translucency, pencil-and-ink taking qualities, workability, permanence. You'll draw easier and faster; get cleaner, sharper prints, in record time.

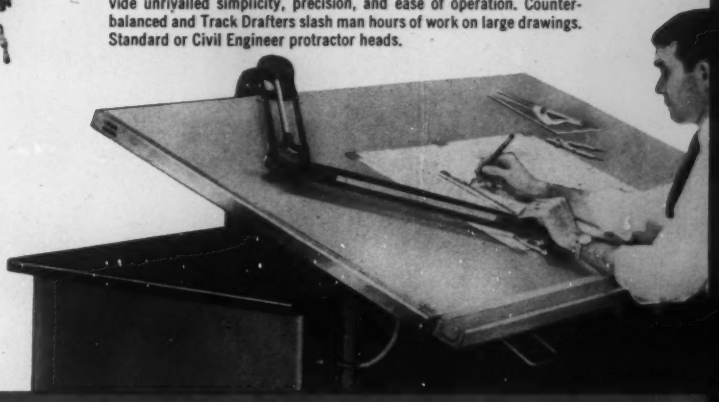
Just Out! New "Visi-Vel" resin-transparentized tracing paper offers up to 25% faster reproduction speed!

MODERN HAMILTON DRAFTING TABLES REDUCE WASTE MOTION AND FATIGUE

Unique design of Hamilton Auto-Shift lets draftsman work on any part of the board, reach reference table and drawers without leaving his seat. And you can put six Auto-Shift tables where you now have four boards with separate reference desks.

MODERN BRUNING DRAFTERS SPEED DRAFTING UP TO 40%

Over conventional equipment, Bruning drafters speed drafting up to 40% on most jobs . . . up to 50% on some structural drawings. Patented "Equipoise" gravity compensator, exclusive touch control indexing provide unriyalled simplicity, precision, and ease of operation. Counterbalanced and Track Drafters slash man hours of work on large drawings. Standard or Civil Engineer protractor heads.



MODERN COPYFLEX MACHINES AND SENSITIZED PAPERS, CLOTHS AND FILM

Speed Reproduction! New, advanced Copyflex models bring you faster reproduction speed and a host of operator conveniences such as fast return of originals, automatic separation, front or rear delivery. And all the benefits of diazo black-on-white reproduction, plus problem-free operation and installation. No fumes, no exhaust ducts. There's a Copyflex model to meet every need and budget. New, better Copyflex sensitized materials work together with Copyflex machines to speed reproduction, give you premium results.

Slash Re-Drafting Time! Save up to 90% tracing time by making modern Copyflex intermediates (translucent prints) of drawings to be re-worked. Mask out unwanted portions before reproducing the intermediate, add new lines or sharpen up weak lines on the intermediate itself, produce sharp, clear prints from the intermediate.

New Table Top Model 300

New Low Cost Model 35

New Faster Model 575

HAMILTON WOOD FILING UNITS

Combine exactly the interchangeable units you need—in higher stacks—to save time and space. Sturdy oak construction.

PLAN HOLD FILING EQUIPMENT

Save time, space, and damage in filing large active plans. Spring-loaded, clamp-style binders eliminate punching, stapling, bolting or folding of plans. Binders are easily mounted in wall racks, floor stands, cabinets. A binder holds up to 150 plans.

MODERN HAMILTON ALL-STEEL UNITSYSTEM FILES SAVE TIME, SPACE; PERMIT ORDERLY EXPANSION

You file drawings and records in units especially designed for them by size and frequency of use. Drawings are easier to file and find, which saves time. UnitSystem's interlocking feature lets you combine exactly the units you need—in higher stacks—which saves space. It lets you expand your filing set-up gradually, efficiently, and economically.

GIVES YOU MORE TO HELP SAVE MAN HOURS . . . ADD MANPOWER TO YOUR DRAFTING ROOM . . .

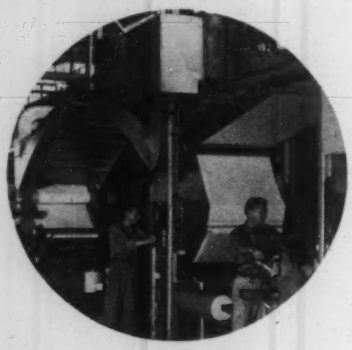
3 more reasons why you can depend on Bruning to help you

Save Man Hours...Add Manpower to Your Drafting Room!

Researcher, manufacturer, and supplier . . . Bruning saves you many man hours by providing a single, convenient, dependable source for everything you need in top-quality drafting room supplies and service. You simplify ordering and stocking, save time and money. You get the following important benefits!

New and Better Products— from Bruning Research and Engineering

Bruning Research and Engineering has introduced such great time-and-work savers as the first pencil tracing cloths, the first fume-free whiteprinters in America, the first band-type drafting machines. Today, by virtue of its modern laboratories and large engineering staffs, Bruning still leads the way. In just the last two years, Bruning has introduced five new, advanced reproduction machines, many newly improved tracing materials. You can count on more new and better products coming to help you save man hours, add manpower.



Consistently High Quality —from Bruning Manufacturing

In its own modern paper converting plants at Teterboro, N.J., Chicago, Kansas City, Los Angeles, and Toronto, Ontario, Bruning controls quality all the way to bring you tracing mediums and sensitized materials of dependable, consistent high quality. The famous Copyflex reproduction machines are entirely Bruning manufactured to provide you the finest in reproduction performance.
You get better results, minimize the risk of trouble and loss of man hours.

▲ 37 Bruning Sales-Service Branches
● 6 Bruning Distributors
◬ 5 Strategically Located Plants

The Product and Help You Need When You Need Them—from Bruning Sales Service

You suffer no costly delays—no loss of man hours—for lack of supply or service. With the most comprehensive network of sales-service branches, distributors, and plants in its field, Bruning assures you of prompt, dependable service and supply.

Your nearby Bruning branch is headquarters for a capable staff of Bruning sales-service specialists who are immediately available to you. Your nearby Bruning branch or distributor carries a full line of Bruning products and is staffed and equipped to give you fast, efficient supply.

Right now is the time to capitalize on Bruning's great time-and-work saving products and Bruning's outstanding service and supply. They work together to help you save man hours—add manpower to your drafting room, now when you need it!

BRUNING

America's Leading Supplier of Engineering and Drafting Equipment

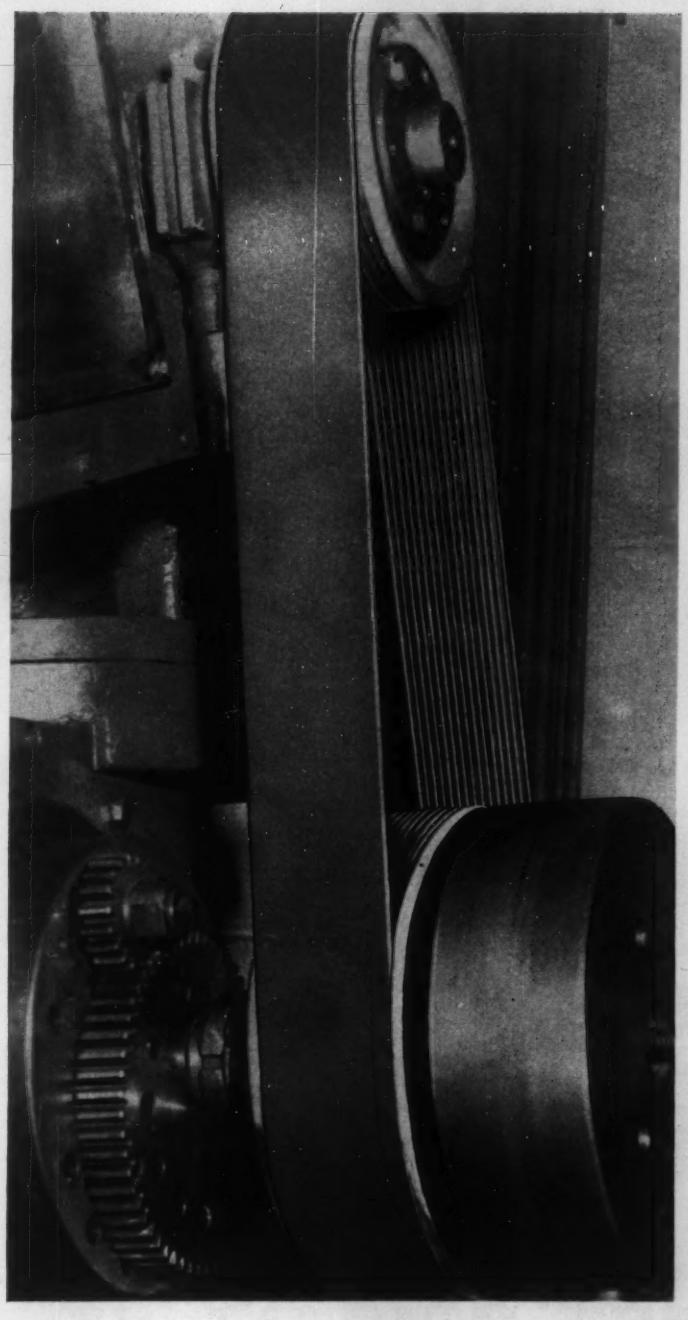
CHARLES BRUNING COMPANY, INC., 4700 MONTROSE AVE., CHICAGO 41, ILLINOIS

In Canada: Charles Bruning Co. (Canada), Ltd., 105 Church Street, Toronto 1, Ontario

A-2320-A

Printed in U.S.A.

No Other Belt Drive Delivers as Much Power in as Little Space as R/M *Poly-V® Drive!*



Here's the answer to space saving design problems for heavy duty power driven machinery and equipment. Use of R/M's patented Poly-V Drive on this planetary miller almost doubled power capacity of the machine's drive . . . *without* increasing space requirements! Space saving advantages of this new concept in power transmission can improve drive design for a wide range of applications.

Single Unit Design

Poly-V Drive employs a single, endless parallel V-ribbed belt running on sheaves designed to mate precisely with the belt ribs. Single unit design gives Poly-V twice the tractive surface per inch of sheave width . . . to deliver up to 50% *more* power in the same space as a V-belt drive—*equal* power in as little as ⅔ the space! This means *less* shaft overhang, less bearing load . . . a compact, *lighter* drive.

Greater Drive Dependability

Poly-V's single unit design completely eliminates belt matching problems, helps maintain constant pitch diameter and speed ratios from *no* load to *full* load. You get longer drive life, greater drive dependability because drive performance is not limited to individual belt life or efficiency. And—just *two* cross sections of Poly-V Belt meet every heavy duty power transmission requirement!

R/M engineers who developed Poly-V Drive will be glad to assist you in determining the installation that will solve your design problems . . . give you "More Use per Dollar." Contact the R/M representative nearest you . . . or write for Poly-V* Drive Bulletin #6638.

**Poly-V is a registered Raybestos-Manhattan trademark*

RM736

BELTS • HOSE • ROLL COVERINGS • TANK LININGS • INDUSTRIAL RUBBER SPECIALTIES

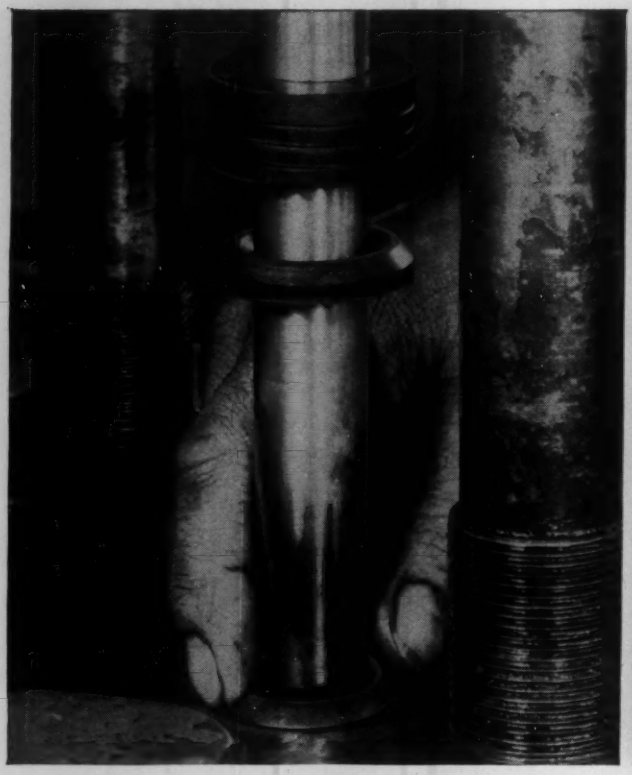
MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.

Other R/M products: Abrasive and Diamond Wheels • Brake Blocks and Linings • Clutch Facings • Asbestos Textiles • Mechanical Packings • Engineered Plastics • Sintered Metal Products • Industrial Adhesives • Laundry Pads and Covers • Bowling Balls

Circle 426 on page 19

CALL ON R/M ENGINEERING SERVICE



CAN YOU PICK THE RINGS WITH THE ORIGINAL VEE-FLEX DESIGN?

DESIGNED FOR EVERY PISTON AND ROD • ROCK-HARD RINGS • POLYMER SATURATED FABRIC
PRECISION TRIMMING • PROPER INTERFERENCE FOR AUTOMATIC SEALING

On the basis of appearance alone, it's impossible to tell which make V-Ring will give you the best service. Performance is what counts.

The original, service-proven convex design V-Ring is R/M Vee-Flex. It is designed for every piston and rod application, is self-sealing and self-adjusting. Its convex design permits automatic flexing on the pressure stroke, producing a positive seal laterally against the stuffing box wall and longitudinally against the adjacent ring.

In R/M Vee-Flex construction, polymer penetration of the fabric is thorough and deep. This, plus rock-hard adapter rings, enables Vee-Flex to withstand pressures up to 6000 psi and more without extruding. In addition, R/M Vee-Flex is precision molded and precision trimmed for exact fit and long service life.

For best performance, specify tough, positive-sealing R/M Vee-Flex, the original convex design hydraulic packing—often copied but never equaled.

For booklet shown, or other data, write, phone or wire:

PACKING DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

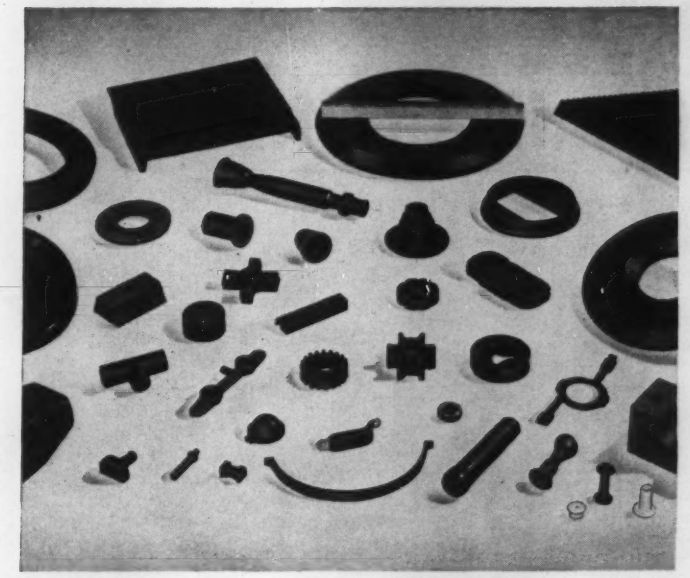
Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

FOR HELP IN SOLVING YOUR PROBLEMS



MOLDED PARTS—Rubber • Silicone

R/M custom-engineered molded parts of natural or synthetic rubber and silicone solve difficult design problems, to resist chemicals, oils, cold-flow, abrasion, extreme temperatures. R/M specialists help you determine the *best* material to meet new product requirements . . . or overcome troublesome conditions caused by materials currently in use. We follow through with the *best* design to assure you long, trouble-free service regardless of temperature or other conditions. Precision manufacturing equipment and modern facilities for quality control, inspection, flash removal give you the benefits of low cost, mass production methods. Rely on Manhattan for molded parts . . . as well as cut and extruded parts to special order, Parock Oilless Bearings for submerged light duty. Where your design calls for any industrial rubber product . . . hose, conveyor, transmission, V-belts, or Poly-V* . . . let R/M specialists work with you.

**Poly-V is a registered Raybestos-Manhattan trademark.*

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000

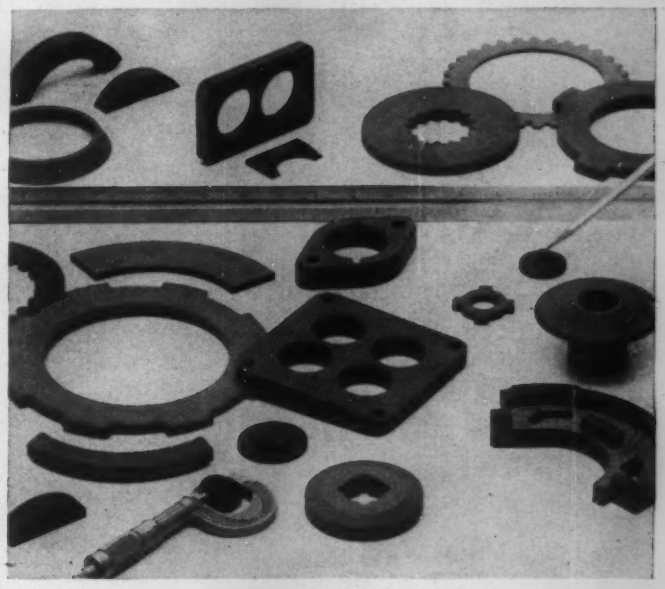
PRECISION MOLDED PRODUCTS

Depending on quantity, size and shape, R/M precision molded products for structural and friction applications not only cost less—because machining is reduced or eliminated. They frequently give better performance as well.

These asbestos parts can be molded to highly accurate dimensions—have high heat stability. They can be designed with specific impact, tensile, compressive and flexural strengths—with a broad range of frictional properties. And they are now being used for a wide variety of applications in the automotive, household appliance, and industrial fields—and in many others. If *you* have a design problem involving small parts, R/M precision molded products may prove to be the exact answer you're looking for.

Write for your copy of R/M Bulletin No. 550. It contains complete design and engineering data on precision molded products.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
Bridgeport, Conn.



RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Industrial Adhesives

Teflon Tape, Packings, Sheets, Rods, Tubes

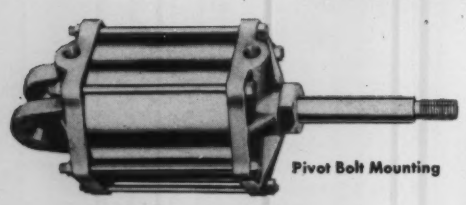
Engineered Molded Rubber and Plastics

Circle 427 on page 19

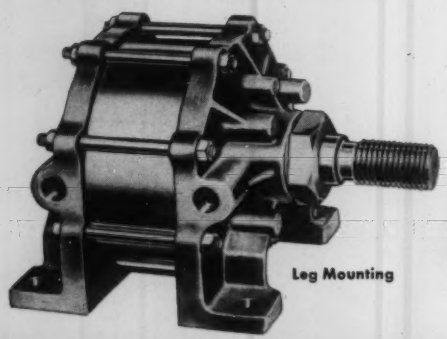
Schrader®...

your one source for AIR CYLINDERS

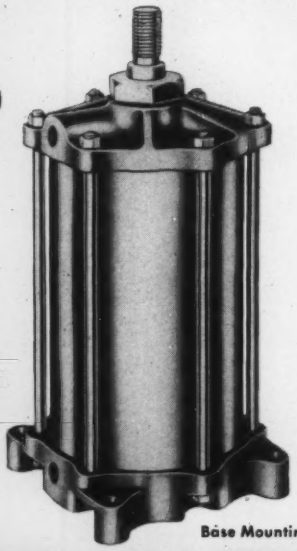
push, pull, single or double-acting, with or without cushion . . . for every type and mounting



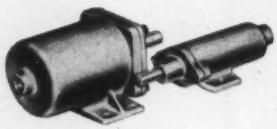
Pivot Bolt Mounting



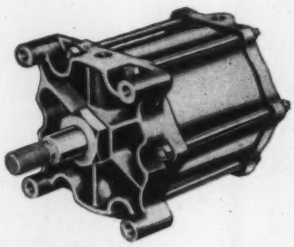
Leg Mounting



Base Mounting



Small Clamping Cylinders



Flush Mounting

VALVES and everything you need in AIR ACCESSORIES

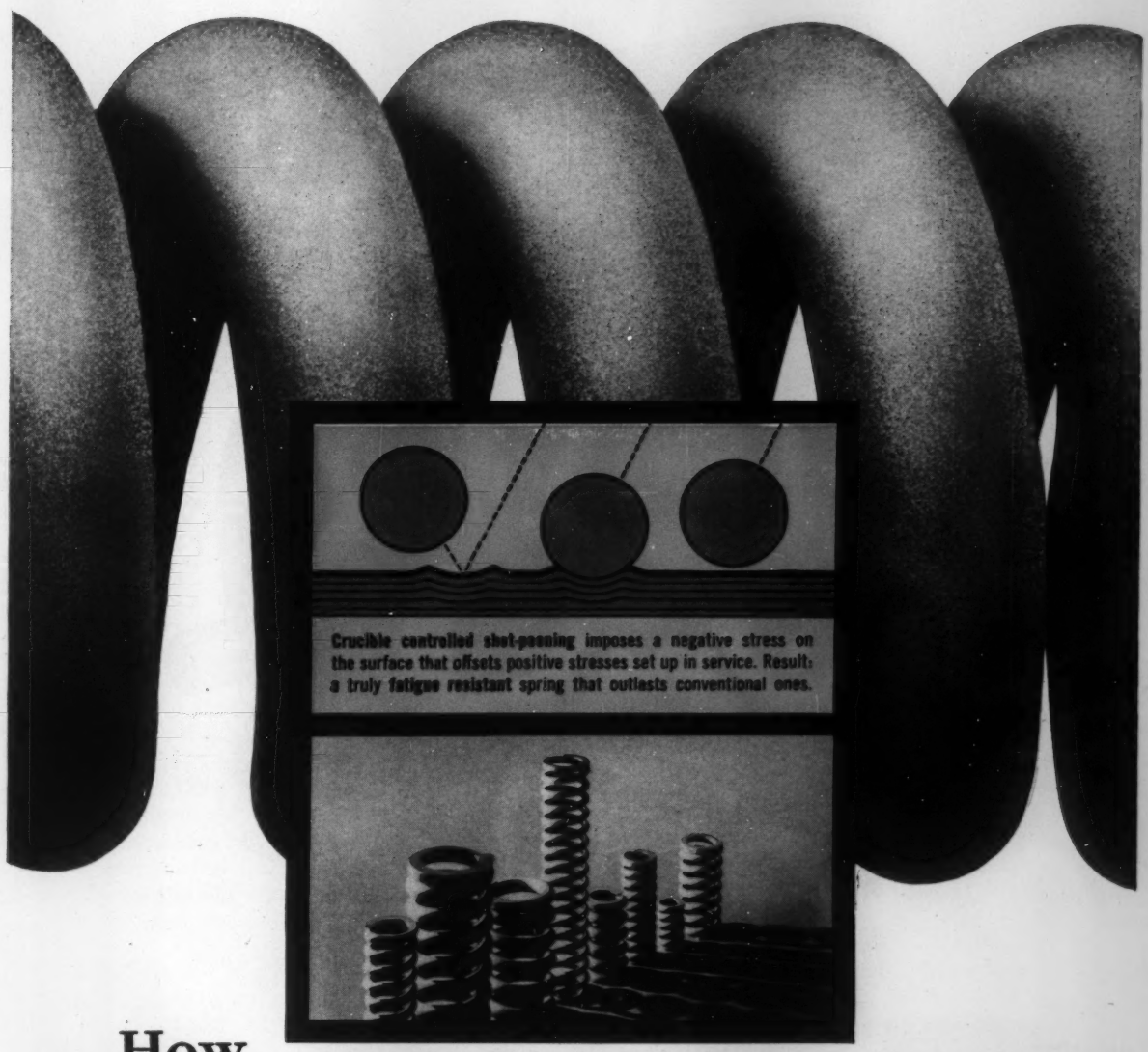
Schrader® a division of SCOVILL

Available for immediate delivery from your Schrader Distributor

A. SCHRADER'S SON • *Division of Scovill Mfg. Co., Inc.* • BROOKLYN 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

Circle 428 on page 19


Crucible controlled shot-peening imposes a negative stress on the surface that offsets positive stresses set up in service. Result: a truly fatigue resistant spring that outlasts conventional ones.

How CRUCIBLE FATIGUE RESISTANT SPRINGS are made stronger to last longer...

First, every Crucible *fatigue resistant* industrial spring is shot-peened. It's the best way to insure high fatigue resistance under rugged operating conditions. And it makes the spring stronger by eliminating stress concentration points that could lead to spring failure.

But, most important, Crucible gives you full measure of the two factors upon which good springs depend: good spring design, and fine steel.

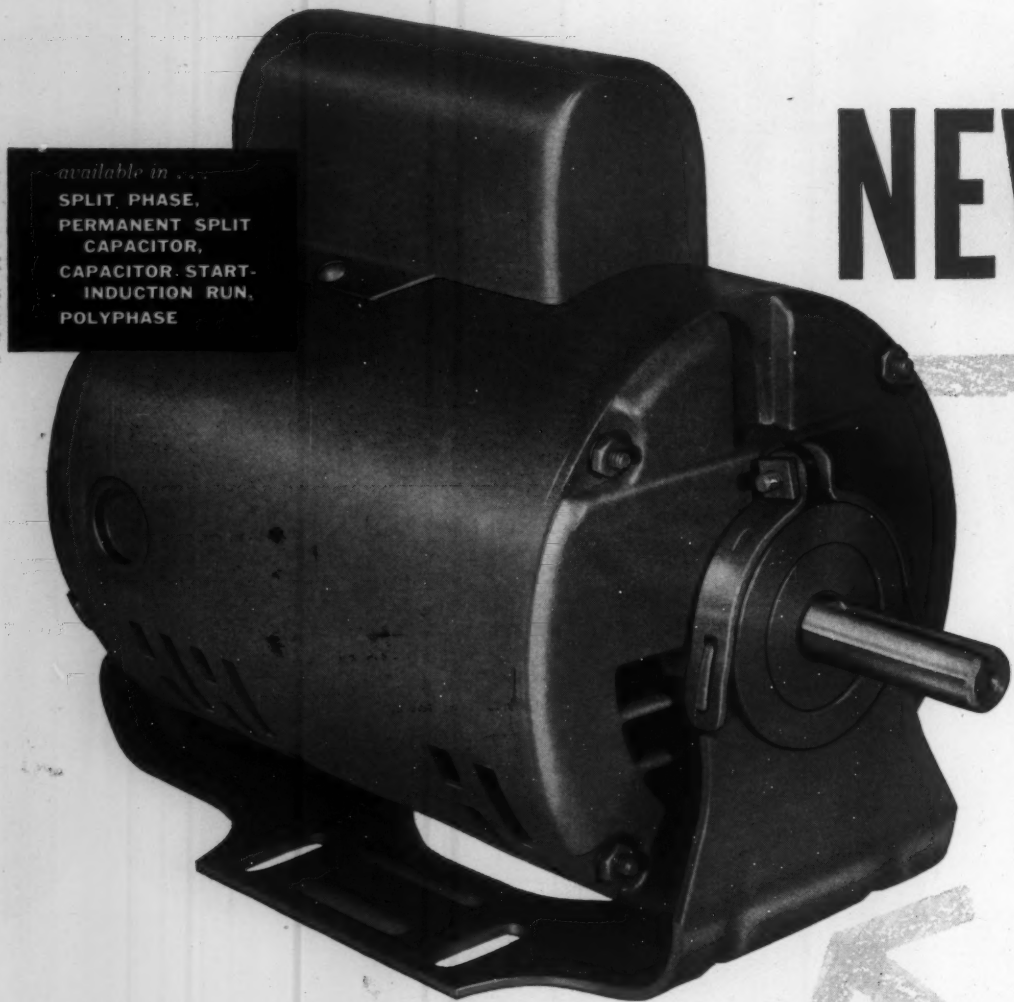
In addition to Crucible's staff of proven spring designers and spring makers is Crucible's years of experience in fine steel making—from ore to finished spring. When you have a spring application, let an experienced Crucible spring specialist suggest the best spring for it. And write for a free copy of the "Handbook of Coil Spring Design". *Spring Division, Crucible Steel Company of America, McCandless Avenue, Pittsburgh 1, Pa.*

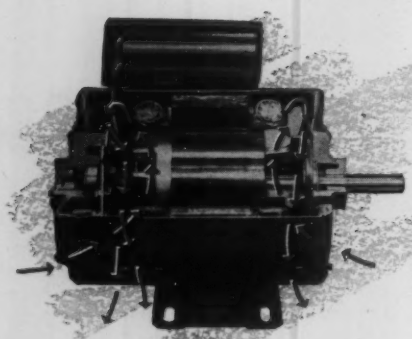
CRUCIBLE spring division

Crucible Steel Company of America

Circle 429 on page 19

NEW!


available in . . .
SPLIT PHASE,
PERMANENT SPLIT CAPACITOR,
CAPACITOR START-INDUCTION RUN,
POLYPHASE


VENTILATION

CLEAN, MODERN DESIGN—Lightweight, die-cast aluminum head ends accurately fit precision machined steel body, assuring rigidity and good alignment. External finish is smooth, flaw-free . . . blends well with any color.

IMPROVED, DOUBLE-END VENTILATION—Ventilating fans are integral with die-cast aluminum squirrel cage rotor, providing effective cooling of the windings from both ends for long life. Properly located openings give maximum cooling with minimum internal parts exposure.

MYLAR* POSITIVE INSULATION—Mylar* polyester film laminated to rag paper insulates slot cells and other strategic areas. Excellent dielectric qualities and resistance to tearing and aging, affording virtually permanent protection against dust, moisture and heat damage.

CHOICE OF MOUNTINGS, BEARINGS—Rigid, welded base or vibrationless, ultra-quiet resilient mounting with motor hubs floating on rubber cushioning rings permanently bonded to inner and outer metal bands. Either sleeve type or fully sealed ball bearings available. If desired, special construction permits re-lubrication of ball bearings. Bearings seat in precision bored steel rings cast into the aluminum heads.

**DuPont registered trademark*

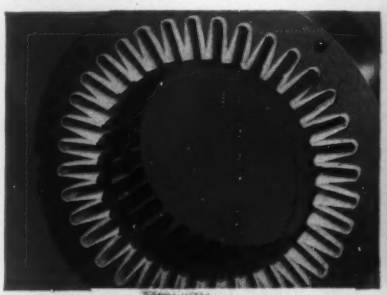
Robbins & Myers build motors from 1/200 to 200 horsepower

R&M

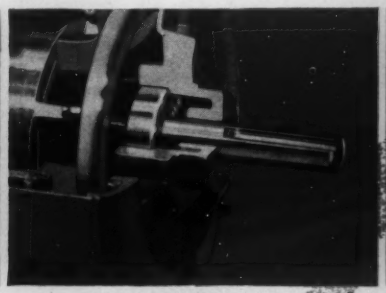
R & M's BROAD LINE OF SMALLER, LIGHTER, FRACTIONAL HP MOTORS

Robbins & Myers Re-Rated Frames 56 and 48

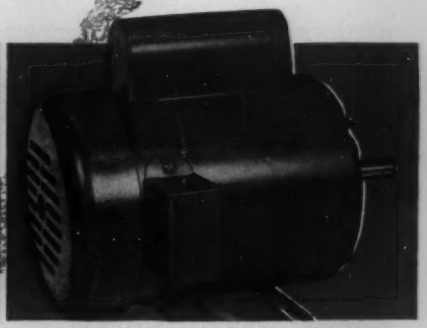
Here's a dynamic new motor—smaller, lighter, more versatile than older frame motors—yet with undiminished performance and reserve power. Completely new R&M "Model R" fractional horsepower motors will perform dependably and enhance the appearance and acceptability of your products. They range from 1 to ⅛ HP in types for all your applications: polyphase, permanent split capacitor, capacitor start single phase and (in the smaller ranges) split phase types. Designed in new NEMA frames 56 and 48, they are *lighter* due to new applications of aluminum, steel and copper . . . *smaller* thanks largely to a unique new ventilating system . . . *more versatile* because of weight, size and many other design features involving frames, mountings, insulation etc. Look over the big advantages these motors offer you! Then write today for R&M Bulletin No. 450—MD.



MYLAR SLOT CELL INSULATION



BEARINGS



TtotALLY ENCLOSED—FAN COOLED

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO — ONTFORD, ONTARIO

LIVE BETTER ELECTRICALLY

MOTORS

FANS

HOISTS

MOYNO® PUMPS

Circle 430 on page 19

You can make design changes simply . . .

and save hours of drafting time . . . with Ozalid's family of intermediate materials

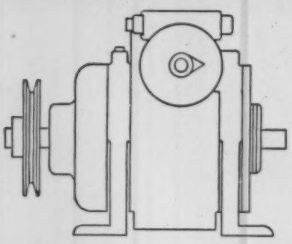
Once . . . just once . . . you run your original drawing through your Ozalid machine with a piece of Ozalid intermediate material. Then file away your drawing. Your Ozalid intermediate copy becomes a duplicate original—all set to give you important benefits.

Take design changes, for instance. With an Ozalid intermediate print, there's no need to trace or redraw the original design. Changes are as easy as 1-2-3 . . . just see below!

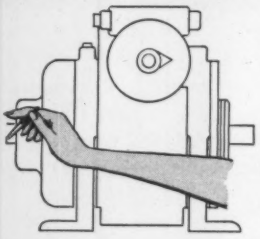
Not only are Ozalid intermediate prints exact copies of your original—they can be *better* than the original. Faded or weak areas are intensified.

There's an Ozalid intermediate material for every drafting room need: film, translucent paper, and cloth.

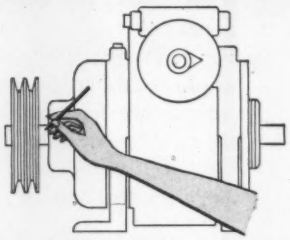
See for yourself how quick and easy you can make design changes with Ozalid intermediates. Contact your local Ozalid man—his name is in the phone book—or write for free folder. Write to Ozalid, Dept. GG-10, Johnson City, N. Y. In Canada: Hughes Owens Co., Ltd., Montreal.



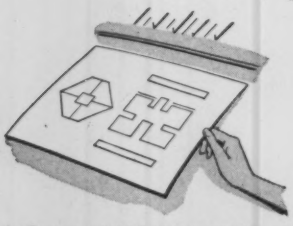
1. This is an Ozalid intermediate (translucent) print of the original drawing.



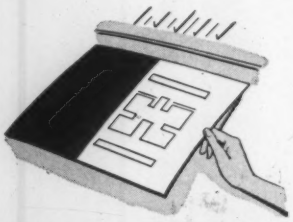
2. Draftsman eradicates obsolete lines with Ozalid Corrector Fluid.



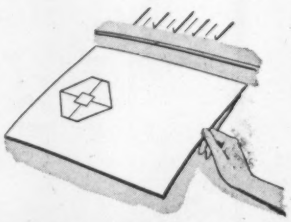
3. New design is drawn in. Prints can now be run from this intermediate "master."



1. Expose original drawing in the usual manner on Ozalid intermediate paper, cloth, or foil. But do not develop!



2. Cover all printed yellow lines which are to be retained on the intermediate with a mask of black opaque paper—re-expose in Ozalid machine. The light will remove all obsolete details left uncovered.



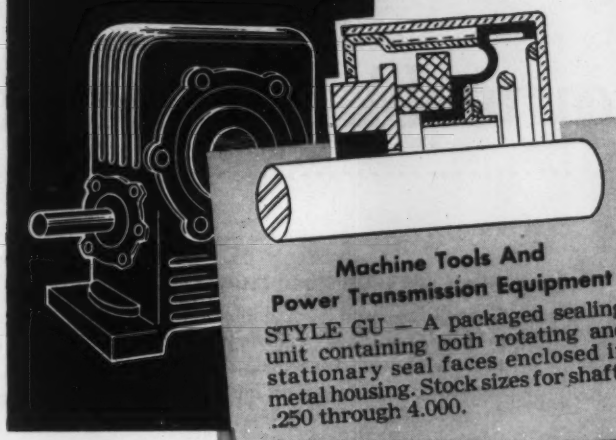
3. Develop the intermediate . . . and you have a clear, up-to-date "framework" to which you add the new design. Use this intermediate master to produce prints.

OZALID®

Products for Design

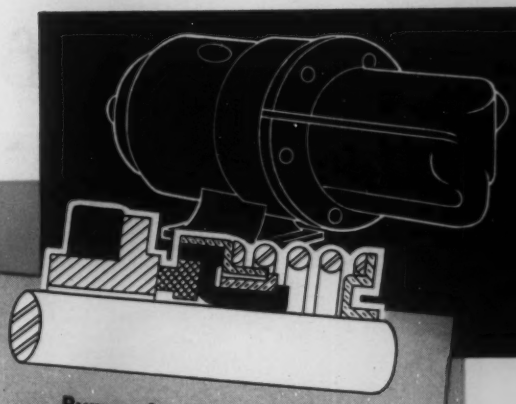
A Division of General Aniline & Film Corporation
In Canada: Hughes Owens Company, Ltd., Montreal

Circle 431 on page 19



Machine Tools And Power Transmission Equipment

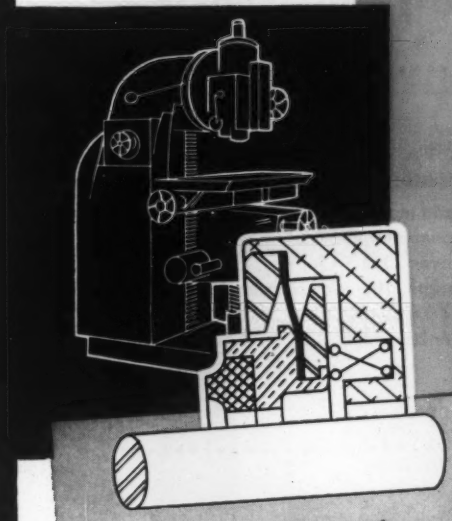
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

A Complete Line

GITS SHAFT SEALS

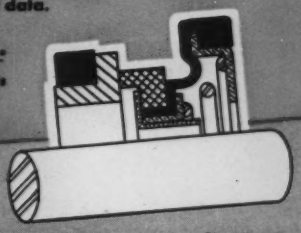
For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

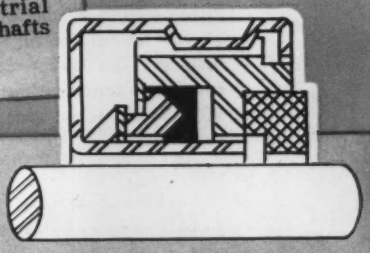
1868-A South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



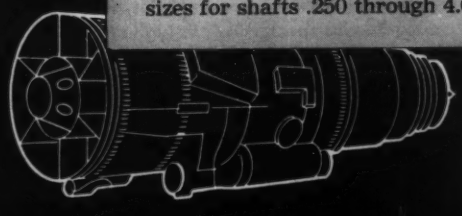
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



Circle 432 on page 19

Designers! If you seek a specific

Alloy 2011-T3: Good Machinability

Copper, lead and bismuth alloying elements in 2011-T3 produce machining qualities similar to those of brass. For example, the electrical connector part shown was machined at a surface speed of 800 SFPM from 1⅜-inch diameter bar stock (eleven machining operations).

Alloy 2017-T4: Greater Strength

Copper, magnesium and manganese are the principal alloying elements in 2017-T4, giving it increased properties over 2011-T3 for parts requiring greater strength. The camera part shown was machined of 2017-T4 at 400 SFPM from 1½-inch diameter bar stock.

Alloy 2024-T4: The Aircraft Alloy

This alloy, containing copper, magnesium and manganese, has higher properties than either 2011 or 2017. Accordingly, it is widely used for aircraft fittings and all types of threaded fasteners. The AN fittings shown (all of which satisfy AN specifications) were machined of 2024-T4 at various speeds and from various sizes of stock.

Alloy 6061-T6: High Corrosion Resistance

Magnesium, silicon, chromium and copper alloying elements give 6061-T6 superior corrosion resistance and excellent finish when anodized. In the part shown, which is used in a grounding assembly for telephone and television equipment, 6061-T6 was specified for its high resistance to corrosion in outdoor atmospheres. The part was machined from ¾-inch diameter bar stock at 350 SFPM (9 machining operations).

property and/or a combination,

converting from brass or steel to aluminum alloys for screw machine parts gives you almost unlimited design flexibility! For example, each of the four parts shown is machined from an aluminum alloy selected to meet a specific design requirement . . . yet all four offer a combination of excellent machinability, superior finish, lighter weight, ease of production. A Kaiser Aluminum engineer will help you utilize these properties in . . .

KAISER ALUMINUM

THE BRIGHT STAR OF METALS

For complete information and expert assistance, look for the number of our nearest sales office in your classified telephone directory, or call one of our many distributors.

Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Ill.; *Executive Office*, Kaiser Bldg., Oakland 12, Calif.

SEE "MAVERICK" • SUNDAY EVENINGS, ABC-TV NETWORK • CONSULT YOUR LOCAL TV LISTING

SOME OF THE MANY PARTS WHERE ALUMINUM IMPROVES DESIGN!

Automotive
- Hydraulic brake parts
- Carburetor shafts and connectors
- Fuel pumps
- Speedometer cable collars
- Oil and fuel gauge bushings
- Distributor parts
- Parking light connectors

Appliances
- Clock and mechanical timer posts and bushings
- Electric dryer components
- Garden hose fittings
- Gas appliance line connectors
- Electrical switch parts
- Temperature control device components
- Vacuum cleaner motor brush holders

Electrical Equipment
- Connectors, industrial power line
- Connector bodies, quick disconnect types
- Lighting fixture components (knobs, finials, etc.)
- Motor plugs and spacers (D.C. small)
- Transmission hardware
- Watt-hour meter components
- Wiring device switch and knobs

Industrial Equipment
- Builders hardware components
- Fittings, hydroulic tube
- Hand tool parts
- Laboratory apparatus components
- Mechanical measuring instrument components
- Portable power tool parts
- Textile spindle shanks

Circle 433 on page 19

NOW

for the first time

LOW COMPRESSION SET

Butyl "O" RINGS

NEW

Another LINEAR first . . . a new, low compression-set Butyl Compound for use in "O" Rings. LINEAR Butyl Compound 7806-70 is a seal material that withstands compression set at elevated temperatures without being permanently deformed or losing its resiliency and its value as a seal. Also, Butyl withstands the chemical actions of the non-flammable phosphate esters such as "Skydrol", "Pydraul", "Celluflex" and "Lindol".

YET, PROVEN

Exhaustive tests, under method "B" of the ASTM, show this new LINEAR compound develops only 30 to 40% compression set after 70 hours at 212°F, as compared to the usual 70 to 95% set experienced with previous Butyl compounds. This unusually good resistance to permanent deformation, combined with a tensile strength of 2000 psi and an elongation factor of 275%, make this material an outstanding one for all "O" Ring applications and other molded shapes where Butyl rubber's excellent qualities are desirable.

Whenever you have a seal problem that is tough to handle—look to LINEAR for an answer. Write, or ask the local representative for complete information on LINEAR's new Butyl Compound 7806-70—today.

"PERFECTION IN RUBBER"

LINEAR

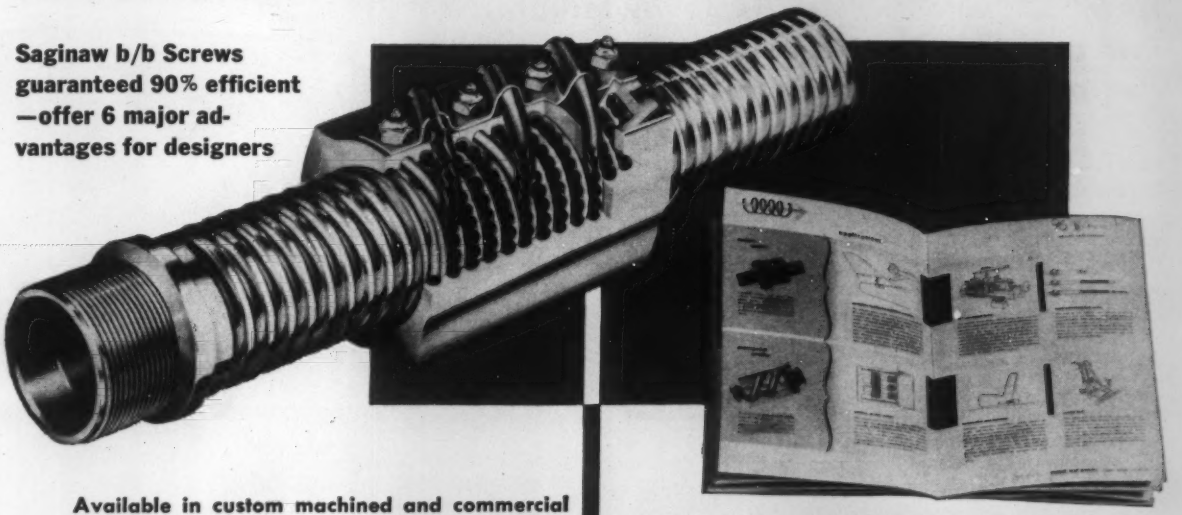
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

Circle 434 on page 19

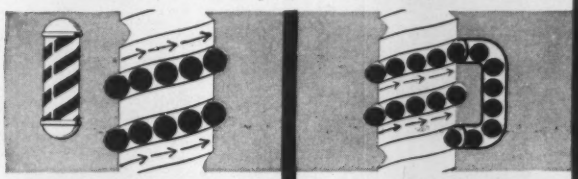
ACTUATION PROBLEM too tough for ordinary devices?

SAGINAW CAN HELP YOU SOLVE IT!

Saginaw b/b Screws guaranteed 90% efficient —offer 6 major advantages for designers



Available in custom machined and commercial rolled thread types—have been built from 1½ inches to 39½ feet long—⅜ to 10 inches diameter.



Nut *glides* on steel balls. Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.

At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

1 VITAL POWER SAVINGS. With guaranteed efficiency of 90%, Saginaw b/b Screws are up to 5 times as efficient as Acme screws, require only ⅕ as much torque. This permits much smaller motors with far less drain on the electrical system. Circuitry is greatly simplified.

2 SPACE/WEIGHT REDUCTION. Saginaw b/b Screws permit use of smaller motors and gear boxes; eliminate pumps, accumulators and piping required by hydraulics. In addition, Saginaw b/b Screws themselves are smaller and lighter. Units have been engineered from 1½ in. to 39½ ft. in length.

3 PRECISE POSITIONING. Machine-ground Saginaw b/b Screws offer a great advantage over hydraulics or pneumatics because a component can be positioned at a predetermined point with precision. Tolerances on position are held within .0006 in./ft. of travel.

4 TEMPERATURE TOLERANCE. Normal operating range is from −75° to +275° F., but assemblies have been designed in selected materials which function efficiently as high as +900° F. These units are practical where hydraulic fluids have lost efficiency or reached their flash point.

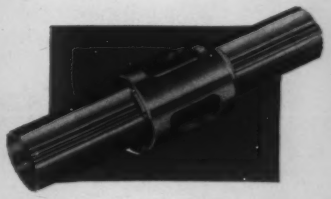
5 LUBRICATION LATITUDE. Even if lubrication fails or cannot originally be provided because of extreme temperatures or other problems, Saginaw b/b Screws will still operate with remarkable efficiency. Saginaw units have been designed, built and qualified for operation without any lubrication.

6 FAIL-SAFE PERFORMANCE. Far less vulnerable than hydraulics. In addition, Saginaw offers three significant advantages over other makes: (1) Gothic arch grooves eliminate dirt sensitivity, increase ball life; (2) yoke deflectors and (3) multiple circuits provide added assurance against operating failure.

YOUR FREE COPY OF THIS NEW b/b SCREW AND SPLINE "PROBLEM SOLVER" SHOWS HOW

36 pages crammed with time-, work-, and money-saving facts: Principles • Types • Basic Operations • Coupling Methods • Efficiency • Advantages • Selection Factors • Design Data • Sample Problems

SAGINAW b/b SPLINE



● Averages 40 times lower coefficient of friction than ordinary sliding splines!

Utilizing the same basic *gliding ball* principle, Saginaw has developed the *Saginaw b/b Spline* which radically increases the efficiency of transmitting or restraining high torque loads.

It can be fitted with integral gears, clutch dogs, bearing and sprocket seats, etc. Units have been built from 3 inches to 10 feet long—⅜ to 6 inches in diameter.

SEND TODAY FOR THIS FREE 1957 ENGINEERING DATA BOOK...

or see our section in Sweet's Product Design File

Saginaw ball bearing Screws and Splines

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS

WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. 7H, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

NAME_____

COMPANY_____ TITLE_____

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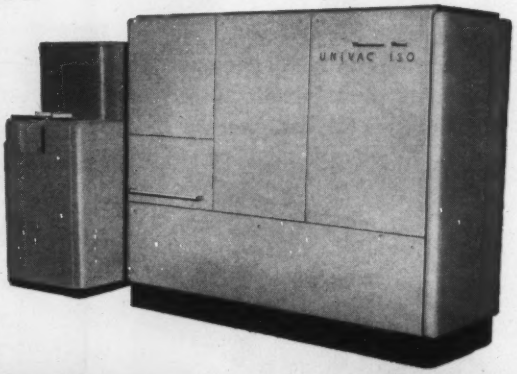
SHORTER "THINK-TIME" FOR UNIVAC COMPUTER WITH WARNER ELECTRIC BRAKES AND CLUTCHES

New "SF" and "RF" units easily integrated into complex control circuit . . . simple design an important factor

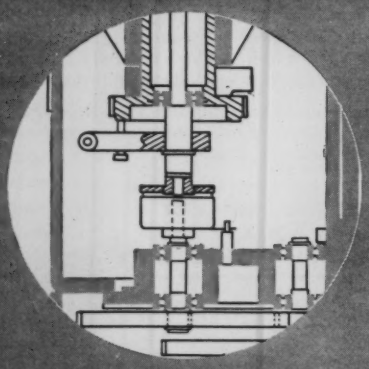


How can an electronic brain be made to think faster? Remington Rand Division of Sperry Rand Corporation found that Warner Electric Brakes and Clutches definitely speeded up the operation of the UNIVAC 60-120 Electronic Computer. Their simple, rugged design reduced maintenance as well—another important salability factor of complicated computing machines.

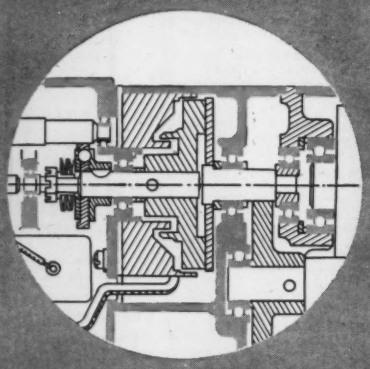
The UNIVAC 60-120 is a two-element automatic arithmetical computer. One element rapidly and continuously "reads" data from punched cards, transmits problems to the other—computing—element, and records the answers by punching them into the cards. The electric brakes and clutches control automatic start-stop cycle of the sensing and punching element between operations. Positive *20-millisecond stops* are accomplished by the RF-250 brake. Compact three-part design was important in the selection of the Warner units, which consist only of a magnetic field, an armature, and a replaceable face or rotor. Torque is easily controlled, and adjustment is never necessary.

Warner Electric Brakes and Clutches offer split-second operation and precise control for automatic cycling, indexing, positioning, starting, and stopping. Specify them on small machines, instruments, and servo drives. Give your machines the control advances your customers want. Now available in capacities ranging from 125 to 700 ft lb, maximum static torque ratings.

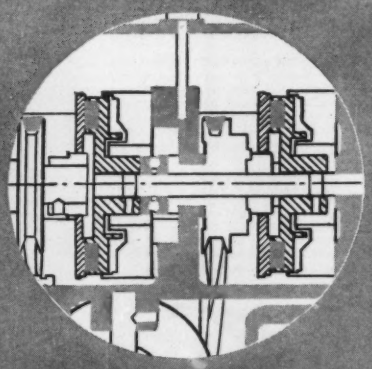
EASILY SOLVE POWER PROBLEMS LIKE THESE



Clutch-coupling for packaging machine—Stationary field clutch serves as revolution-counting device for filling mechanism. Armature is keyed to spring-loaded counter arm that rotates through arc to contact limit switch. Rotor is keyed to shaft coupled through gearing to auger drive shaft. Auger drive clutch and counter clutch are energized simultaneously. When arm contacts switch, clutches are de-energized and brake is energized to stop auger drive shaft.

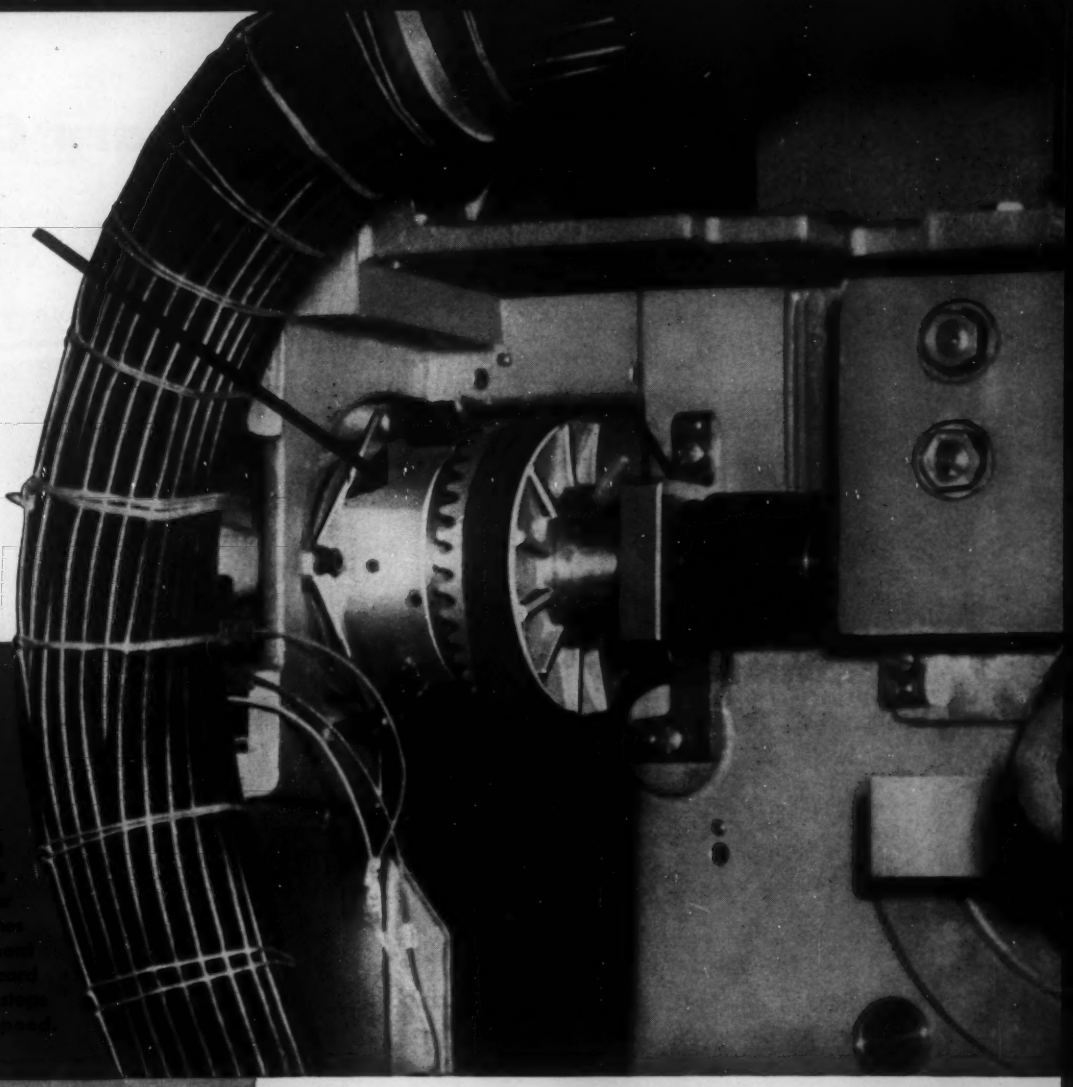


Clutch for power steering unit on the tail wheel of an airplane. Stationary field unit with the rotor keyed to shaft of drive motor, armature keyed to output shaft to rotary actuator. Energizing clutch couples drive motor to output shaft to rotary actuator which turns tail wheel in phase with the rudder. When wheel swivels in phase with the rudder, pilot can taxi plane in the direction he wants, regardless of mud or snow on landing strip.



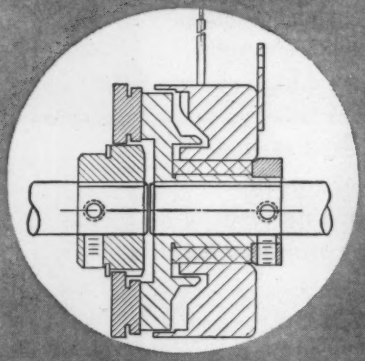
Clutch-coupling for tapping machine—Two stationary field bearing-mounted clutches on lead screw give downfeed and reversing drive with continuous-running, nonreversing motor. For downfeed, armature is keyed to motor drive shaft, rotor mounted on lead screw drive shaft, field mounted on bracket. For reversing, armature is bearing-mounted to sheave driven by vee-belt from idler pulley, rotor keyed to lead screw drive shaft and field mounted on bracket.

Fast, smooth-functioning Warner Electric Brake and Clutch reduce time losses between steps and calculations.



The UNIVAC is an automatic punched-card electronic computer. The computing element does 360,000 verified additions or subtractions or 72,000 verified multiplications or divisions per hour. Warner Electric Brakes and Clutches help the sensing element efficiently synchronize card "reading" and punching steps with this tremendous speed.

Each cycle of the sensing and punching element is started and stopped electrically. A drive belt from a one-third horsepower electric motor is geared to the shaft on which the Warner units are mounted. The masses of connecting wires visible here give an idea of the extreme complication of the processes synchronized through Warner's fast starts and *20-millisecond stops.*



Tipmaster clutch-coupling for office machine—The field of SF-250 electric clutch is bearing-mounted to drive shaft, and the rotor is keyed to drive shaft. The armature transmits power to the driven shaft by means of a splined hub. Motor runs continuously and the clutch-coupling engages power to driven shaft until the limit switch opens the clutch circuit and de-energizes coil. Simple design cuts assembly time 60 per cent.

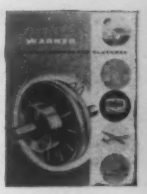
Circle 436 on page 19

Beat competition with

ELECTRIC BRAKES AND CLUTCHES

Warner Electric Brake & Clutch Co.
Dept. MD, Beloit, Wisconsin

Please send me copy of your new Condensed Catalog No. 6212.



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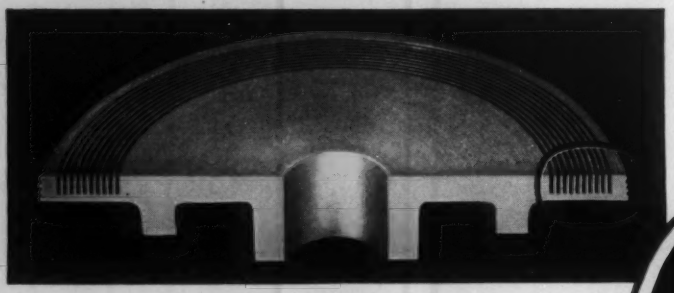
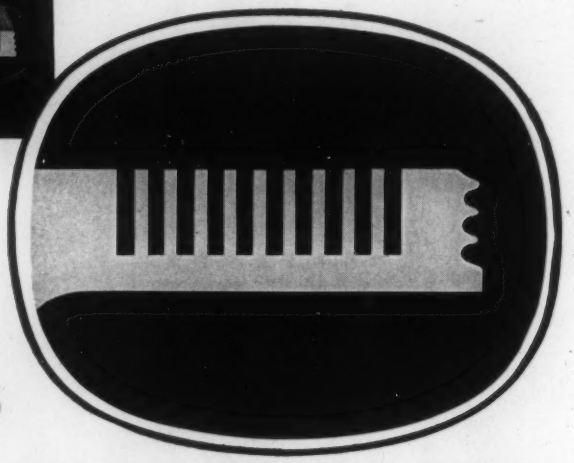
Company_____

Address_____

City_____ State_____

Do Your Castings Require Sharp Corners *Like These?*





The Denser Structure of EATON PERMANENT MOLD GRAY IRON CASTINGS

Permits the Machining of Precise Corners

The fine dispersion of graphite in Eaton Permanent Mold Iron and its dense, non-porous, homogeneous structure make it an ideal material for many difficult machining operations where accurate dimensional results and sharp corners are essential.

Because its superior structure permits the machining of extremely thin sections and has the ability to take a high surface finish, Eaton Permanent Mold Iron is recommended for such critical applications as bearing retainers, connecting rods, pulleys, carburetor bodies, valve bodies, and service valves.

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The part shown above required that 10 grooves, .023" wide and .125" deep, leaving 9 lands .015" wide, be rapidly and simultaneously machined. Eaton Permanent Mold Iron proved to be the ideal material—completely eliminating the problem of curling chips in the small grooves, and crumbling of lands during machining.

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Circle 437 on page 19

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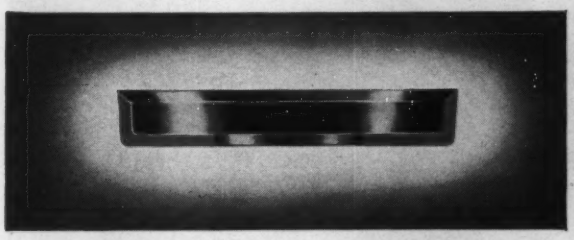
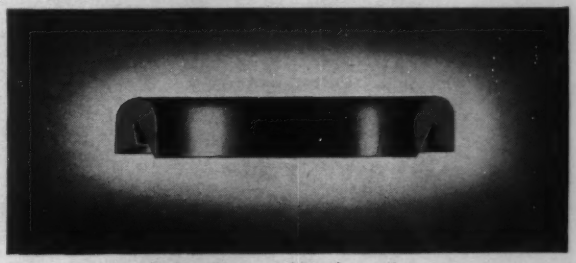
with Johns-Manville Precision moulded packing designs for pressure applications in hydraulic and pneumatic equipment

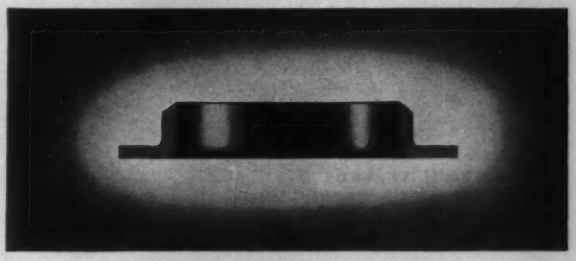


1. Type "A" Packing Cups for pistons *(the original "square heel" cup design)*

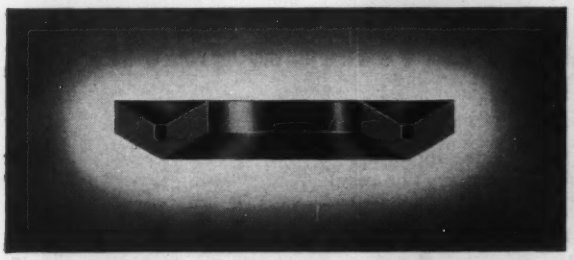


2. Sea Ring packing for rods

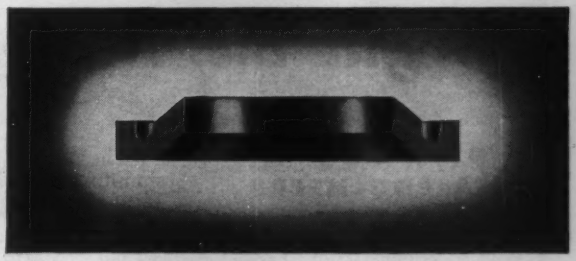
3. Uneepac Packing for rods and pistons



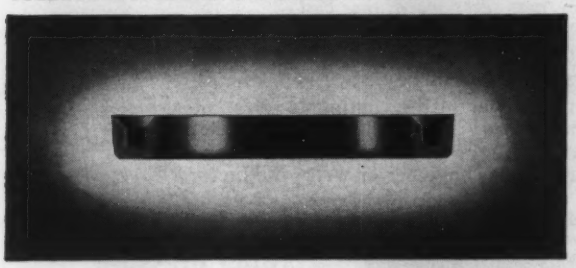
4. Hat Cup Packing for rods



5. V-Rings packing for rods and pistons



6. Cumpac #239 packing for rods



7. U-Cup Packing for rods and pistons

THE WIDE VARIETY of Johns-Manville Packing designs enables you to handle practically any sealing problem. The designs shown on this page are obtainable in a broad range of standard sizes and in materials designed for either usual or special service conditions encountered in hydraulic and pneumatic equipment. Johns-Manville also produces oil seals, moulded gaskets and miscellaneous shapes to specification. See your local J-M distributor or J-M sales office for product or engineering data. Or write Johns-Manville, Box 14, New York 16, N.Y. In Canada, Port Credit, Ontario.

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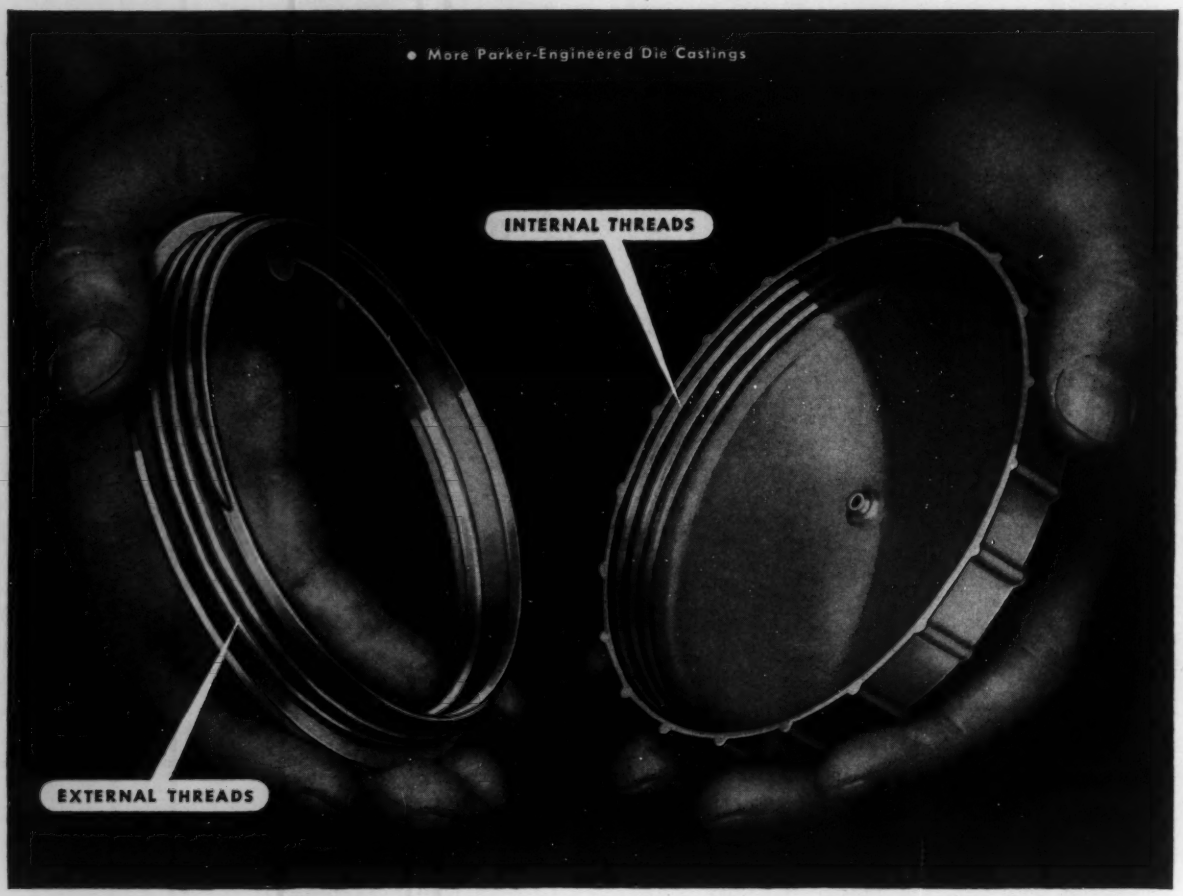

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These two mating parts, including the threads, are cast simultaneously in the same die. The result—three savings:

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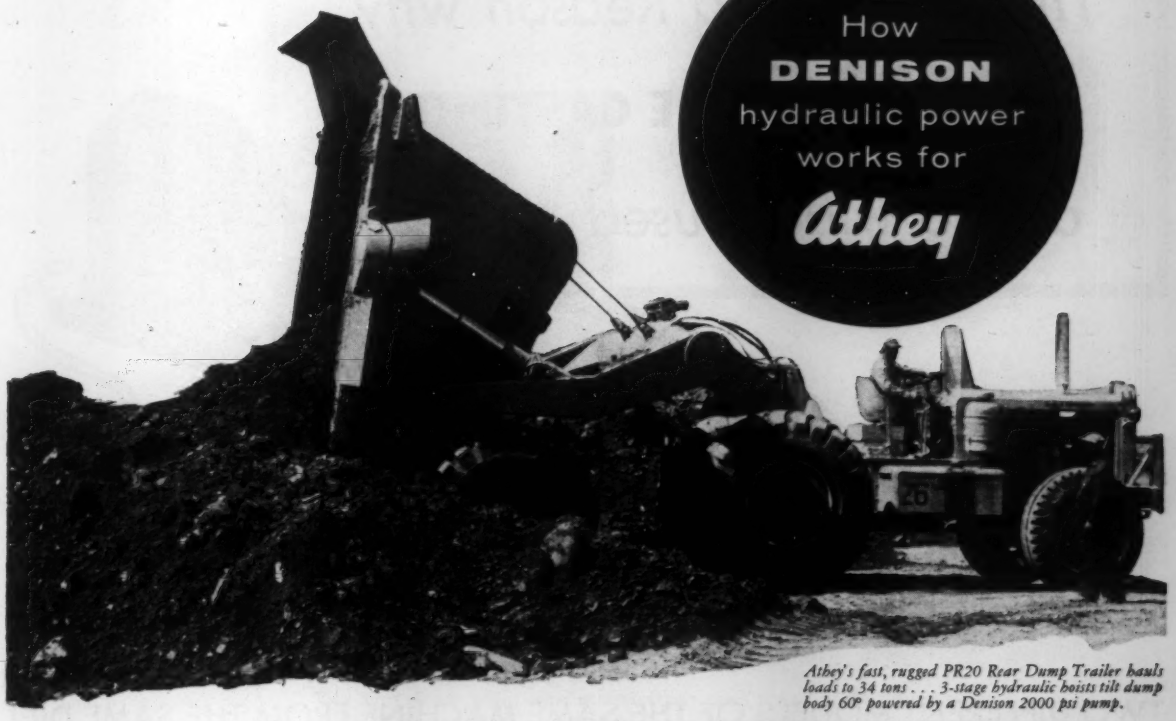
Circle 439 on page 19

How **DENISON** hydraulic power works for *Athey*



Athey's fast, rugged PR20 Rear Dump Trailer hauls loads to 34 tons . . . 3-stage hydraulic hoists tilt dump body 60° powered by a Denison 2000 psi pump.

34-TON PAYLOAD DUMPED ON THE DOUBLE

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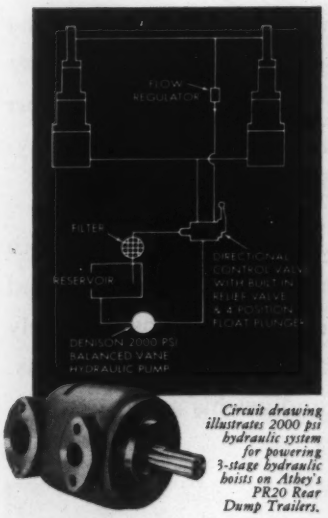
FLOW REGULATOR
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DIRECTIONAL CONTROL VALVE WITH BUILT-IN RELIEF VALVE & 4 POSITION FLOAT PLUNGER
DENISON 2000 PSI BALANCED VANE HYDRAULIC PUMP

Circuit drawing illustrates 2000 psi hydraulic system for powering 3-stage hydraulic hoists on Athey's PR20 Rear Dump Trailers.

Denison 2000 psi vane-type hydraulic pump.

TODAY'S high-speed earthhauling operations call for *fast dumping* to save valuable minutes . . . where minutes are big money. That's why Athey Products Corporation depends on Denison hydraulic power to dump its PR20 Rear Dump Trailers quickly, completely.

Each 34-ton capacity trailer is equipped with one-lever hydraulic controls . . . and 3-stage, double-acting hydraulic hoists that tilt the dump body 60°.

A single Denison 2000 psi balanced-vane hydraulic pump, driven by the tractor engine's power take-off, extends the hoists . . . dependably, efficiently. That's because there's generous reserve stamina in the Denison pump to meet toughest work conditions.

With the Denison "T" Series pump, Athey designers assure all-weather pump-starting ability. Field servicing is speedy because the complete pumping cartridge is removable as a unit. *Result: lower operating cost . . . dependable continuous performance.*

There's less weight, less cost-per-horsepower—with smaller lines and valves with the Denison 2000 psi pump as the heart of a hydraulic system. Design flexibility is unlimited.

Have your Denison hydraulic specialist tell you more about how the 2000 psi pump can improve performance of your equipment. Write Denison Engineering Division, American Brake Shoe Co., 1240 Dublin Road, Columbus 16, Ohio.

DESIGNERS—ENGINEERS! New Bulletin 201 describes "How To Design More Efficient Hydraulic Power Into Mobile Machinery". Write for it.

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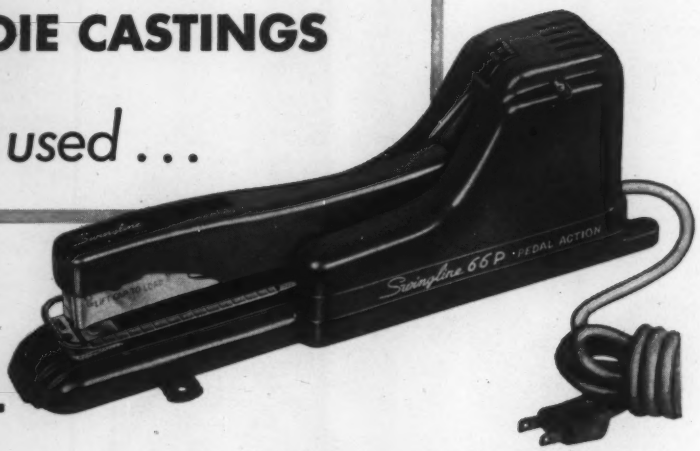

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TWO DIFFERENT MODELS OF THE SAME MACHINE FROM THE SAME DIE!

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Both of these housings for the SWINGLINE feather-touch electric stapler were made in the same die by using a cut-off section to eliminate the long anvil of the standard model. The short stapler is for industrial, laundry and dry-cleaner use.

This FLEXIBILITY of die casting with ZINC offers a great variety of time-saving and money-saving advantages — almost certainly some that can be applied to your products. See your die caster and get his advice.

THE NEW JERSEY ZINC COMPANY

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HORSE HEAD PRODUCTS ®

Circle 441 on page 19

MACHINE DESIGN
October 31, 1957

The Thorny Path

THE centipede's feet were killing him. So the wise old owl told him he should change himself into a man. Because a man has only two feet, his pain and discomfort would be reduced by 98 per cent. "How do I do that?" asked the centipede. "That's your problem" replied the owl, "I only set policy."

You can draw your own moral from that story. We think it points up the dangers of permitting nonengineers to set engineering policy.

Too often management positions have gone by default to sales or financial people. Available engineers just didn't have the temperament or ability to "get things done through others."

Yet managements weak in engineering talent have cost industry, and the country, uncounted millions, largely hidden. Unlike the mediocre engineer, the mediocre manager sometimes can bluster his way out of his mistakes, especially in the higher echelons.

Ambitious young engineers sooner or later reach an important fork in the road. One leads to advanced engineering, the other to management. Both can lead to success, and in both avenues there is a critical shortage of top-notch talent.

Which is for you? Like any engineering decision, your answer to that question ought to be based on information rather than hunch or mere desire. Thus we commend to the attention of young engineers our continuing series of articles on various aspects of engineering management.

Particularly pertinent to the would-be engineering supervisor is H. M. Elliott's article beginning overleaf. The step to first-line supervision is crucial. You have been singled out from the crowd and the eyes of company brass are upon you. Mr. Elliott's article offers a down-to-earth picture of what's ahead if you choose the thorny path to management.

Colin Carmichael

EDITOR

For supervisors who have the task of training other men to become supervisors, and for engineers who want to become supervisors, here are tips on how to do it—and how not to do it.

MANY have felt first-hand the shortage of engineers, although there are some authorities who feel that there is no such thing. In a rapidly expanding organization, the need for engineering supervision is even more critical than the need for engineering manpower. The function of supervision is to organize a program, implement it, and maintain direction. In a word, to know *what* to do must be decided first before working out the details of *how* to do it.

In the author's organization, which has grown more than tenfold in less than five years, the policy has been to develop supervisors from the ranks of engineers wherever possible. This is particularly true in the case of first-line supervision. The merits of such a policy are obvious. To establish any organization on a firm base, there must be a means provided for the members of that organization to grow with it. Even in those instances where individuals have joined the organization with the understanding of filling a position in supervision, it has been customary for the individual to start in an engineering classification, and remain there, for a period of approximately six months.

What does an engineer have to know in order to be a good supervisor? Obviously he must be competent in his field. He must acquire specific knowledge and techniques pertaining to the performance of his job and the operation of the company. These will be discussed later on. Most important, he must broaden his perspective and learn to think as one who directs the activities of others. This is a subtle change, and consequently requires guidance on the part of more experienced personnel.

During the transition period, which occurs both before and after the actual promotion, this guidance is extremely important. This is the period when the characteristics of the man as a supervisor are set.

Areas of Training

A capable supervisor must, in time, become proficient in three main areas: 1. The specific duties of supervision, which involve the knowledge of practices and procedures necessary to direct the operation of an engineering group. 2. Communications, in the management sense; no group operates in a vacuum. 3. Group leadership.

Specific Duties: The most important duty of a supervisor is that of project planning and direction. As an engineer, a competent individual can determine specifically how to design a piece of equipment. However, as a supervisor, he must formulate an overall work plan, which means a schedule with appropriate manning. He must come up with a realistic budget to finance the project. And most important, he must see to it that his engineers keep to that schedule and within that budget. If there is a possibility of exceeding either one or both, he must realize it as soon as possible and do something about it—other than getting ulcers, that is.

Project budgets are only one aspect of the general area of cost estimating. A supervisor should be familiar with estimating techniques, and should know his company's policy of pricing and loadings. Knowing what these various percentages are, what they are for, and why they vary under different circumstances, helps to give him an insight into his company's operation, and will enable him to do a better job.

A good supervisor must also be a good personnel man. He must know the ground rules for merit

The transition

From Engineer To Supervisor

By H. M. ELLIOTT
Radio Corp. of America
Camden, N. J.

increases, and must be able to make fair and equitable recommendations for all members of the group. Even if there is a definite company procedure for periodic review of an engineer's performance, he must make sure that an engineer always knows where he stands. There is no appointed time for criticism or commendation. He must be able to offer guidance to his people, whether it be on a graduate study program, or the pitfalls of buying a house. And lastly, he should always keep in mind the training of a successor.

Communications: The second area in which a supervisor must become proficient is in communications. Information lines must be maintained vertically with the supervisor's superior and with the engineers in the group. Similarly channels must be kept open in the engineering groups on the same level or same project, and with the various service groups supporting the activity.

Communication vertically is important if personnel in the group are to have a proper realization of the job they are doing, and if they are to understand their places in the scheme of things. From the details of a design project, one doesn't suddenly emerge into the "big picture." At each level of an organization, the horizon broadens, and the people at the lower levels should have some knowledge of the broad aspects of the overall operation. They should see a little of the blue sky now and then, as it were. Similarly, those at the higher levels should be constantly aware of the problems of their subordinates to be certain that the overall operation rests on a firm base.

Communication horizontally with similar groups and service groups is also important. Project coordination is vitally necessary, if all parts are to mesh in. An understanding of model shop and factory procedures, rules and regulations of the purchasing department, and the whys and wherefores of the company's drafting structure make for better project planning. Everybody has his problems, and a good supervisor makes an effort to understand them.

Group Leadership: The third area—group leadership—is the most important. This area is more subtle than the other two. In reality, there are no manuals to refer to, no procedure notices to consult. There are certain ground rules, yes, but their application requires judgment and tact. A cookbook procedure is not sufficient.

Quickly, here are some of the attributes of a good leader:

1. He must have the ability to get along with people.
2. He must be able to delegate responsibility and authority.
3. He must be able to make decisions.
4. He must be able to establish and maintain direction. He must be firm without being inflexible, open-minded without losing control.

▶ Transition to Leadership

The three main areas with which a supervisor is concerned have been briefly discussed. The purpose of this article is to elaborate on the third category, which is by far the most important.

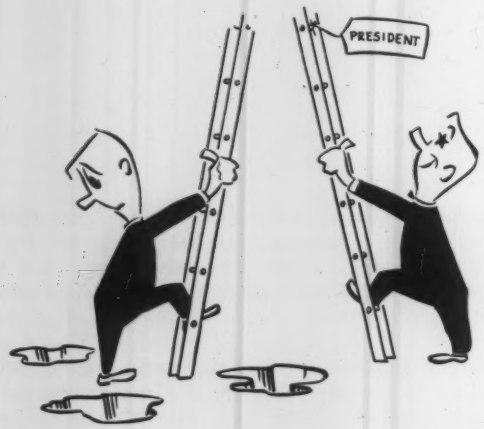
The first two categories cover specific knowledge and techniques which may be learned in time by anyone—assuming reasonable intelligence. The third—group leadership—can only be developed if the characteristics or traits already exist in the individual.

It is the job of experienced supervisors to help the individual develop these characteristics, to

bring them to the fore. A part of this job is to help him realize his abilities and capitalize on them. The whole character of the man as a supervisor is determined at the beginning, during the transition.

For the sake of discussion, assume that the choice has been made, and that it has been a wise one. What follows then is a definite procedure, extending over a year or more. This period may be divided into two obvious parts: 1. The action taken prior to the actual promotion. 2. The action taken after the actual promotion.

Prior to Promotion: This period may be anywhere from six months to a year, depending upon circumstances. Initially no overt indication is given to the engineer. (To reduce the confusion in



the following paragraphs, the selecting supervisor shall be referred to as the "trainer," and the candidate supervisor as the "trainee.")

At this time, the trainee is given more responsibility for the technical direction of the project he is working on. This comes about naturally, since the choice implies that he is a senior engineer, and has already shown some tendency to dominate the group. He takes part, in an advisory capacity, in budget and planning sessions. The trainer takes pains to ask his opinions more often, even about things that possibly he (the trainer) has already inwardly made decisions on, to test the abilities of the trainee.

The trainee is given more and more opportunity to direct work of other engineers. This may be done in a number of ways. For example, with control of the group still resting with the trainer, it is only natural for the engineers to come to him for advice and decisions. This can be gradually steered toward the trainee with such replies as, "Check with X and let me know," or, "Have you discussed this with X? He's had some experience along this line." And later on, "Talk this over with X, and if he agrees, it's all right with me." And when X comes to the trainer for advice or a decision, with increasing frequency the answer should be, in effect, a question: What would you do?

If the trainee's performance has been satisfactory over a period of time, informal discussions should be held, when the opportunity presents itself on the responsibilities of supervision. It should be made clear that as time goes on, the engineering supervisor becomes more of a supervisor and less of an engineer. The emphasis is on administration. The technical aspects—the details of engineering design—become subordinate. This is extremely important. At this point it must be made clear to the trainee that to enter supervision is *not* synonomous with becoming a superengineer.

Finally, the trainer, having been satisfied by the trainee's performance, his orientation, his attitudes, asks: Should the occasion present itself, is promotion to supervision what you really want?

After the Promotion: Assume, now, that the trainee, after mulling things over for a few days answers yes to the question, and conditions are such that the promotion comes through in short-order.

Comes now the critical period in the transition, the time when ideas and attitudes are formed and solidified. At first, there well may be confusion in the trainee's mind. It is not uncommon for the trainee, mentally, to swing between two extremes. On the one hand, flushed with success and pride at having taken the first step up the company ladder, he has visions of becoming president—of the company, at least—and may possibly act accordingly. On the other hand, suddenly concerned with many matters that a short while ago he had nothing to do with or was even unaware of, he thinks he must have been out of his mind for ever agreeing to get into such a rat race, and again, may act accordingly.

This is a time of confusion and reorientation. However, in most cases a pattern emerges and the trainer should be on the lookout for certain tendencies or traits on the part of the trainee.

For example:

1. The new supervisor may try to do everything himself. With increased responsibility, the trainee worries that things are getting away from him. He is afraid to trust his (new) subordinates, even though not too long ago, as his equals, they were completely trustworthy. This is a common tendency which should be corrected—tactfully—as soon as possible.

2. He may tend to delegate responsibility without the necessary authority to accomplish the assigned task. This is an improvement over point 1, since some delegation is in evidence, but it is still not good enough. Most important, this tendency indicates that the trainee still does not trust himself as a supervisor; he lacks confidence in himself. It should be pointed out to him that, by not delegating the necessary authority, he places his subordinates in an untenable position. Also, by not receiving his confidence, they, in turn, will have no confidence in him.

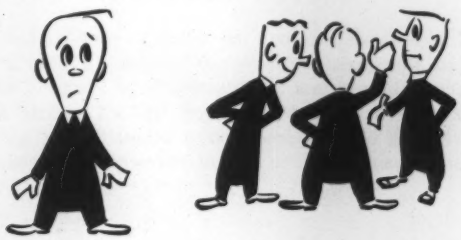
3. Time limits on tasks should be arrived at by discussion, not arbitrarily, and should be checked

on. It should be pointed out that there is nothing to be gained by forcing a subordinate to attempt what he feels is an impossible task, and then berating him for not accomplishing it. It should also be impressed on the trainee that *immediate* commendation or criticism is far more effective than its postponement to some more formal occasion.

4. In general, the trainee should be cautioned against taking to task any member of his group in the presence of other members of the group. Such sessions are better held in private where both parties can blow off steam, if necessary. Just as important, the trainer should be careful not to criticize the trainee unduly in the presence of his subordinates. During the transition, building up a group's confidence in a new supervisor is a slow process and progress should not be jeopardized.

5. Impress upon the trainee that tact is of the utmost importance during this time. The engineers who used to work *with* him now work *for* him. Relationships are in the process of changing. There is bound to be resentment on the part of some of the people initially, even though only subconsciously. This is not to say that the trainee should adopt the attitude of "you know me, Joe, everything is just the same as it has ever been," because it isn't. And the trainee should be aware of the barriers that the engineers are erecting.

6. Conversely, almost every new supervisor starts off with the feeling that he will still be "one of the boys," and that his group is different. This is not so, and he should be warned to expect otherwise. No matter how good a working relationship is established in the group, the trainee is now



someone set apart. He must realize, also, that this difference, however subtle, must exist if he is to retain control of the group. The barrier that arises is invisible, but very tangible. Over a period of time, its presence is felt in many different ways.

7. The trainee must be cautioned to curb the tendency to interfere with an engineer's work in order to "get on with the job." In the beginning at least, the trainee can usually do it faster and better, but such action does not promote harmony in the group, nor does it promote the development of the group as an engineering organization. As time goes on, and the trainee gets away from the detailed technical aspects of the job, he becomes less qualified to personally accelerate the work. Failure to observe this principle can have profound effects, particularly if, over a number of years, the trainee, now an experienced supervisor, progresses in management. This tendency has now solidified into an operating characteristic. The supervisor looks upon himself as a superengineer, who is more expert than the experts, whatever their field. By virtue of his seniority, which he mistakes for experience, he is positive that he knows better, and many times with dire consequences. One cannot interchange experience in engineering direction and administration with experience in engineering design. The fork in the road was reached way back when the engineer agreed that supervision was what he wanted. None can travel both roads successfully, simultaneously.

8. The converse of interference is laxity. The trainee must continually check the progress of his engineers if he is to maintain control. He should never assume that a job will be done; he should verify it for himself, and verify it completely. This means more than a phone call, or the receipt of a progress report. He should make the rounds—of the lab areas, the model shop, or the factory, and see for himself. These visits should be irregular, on no prescribed day or hour.

9. Day-to-day operation is bounded by the limits expressed in points 7 and 8, and requires constant adjustment. There is an art to sensing that something is slipping, and letting it slip just enough so that, when you step in and change assignments, the engineers affected realize you're justified in doing so. Yet, things cannot be permitted to slip far enough to jeopardize the projects. This art can only be learned by experience. The object is to guess wrong a minimum number of times.

10. In general, the trainee must realize that he now has identity with the group. A reciprocal relationship, a sense of mutual trust, must be developed. Just as he must learn to trust the ability of his engineers, so must they learn to trust him. He is the buffer between them and the external world. Within the group, he may criticize, he may reprimand. But outside the group, he is the only

one responsible for the group's actions. The new supervisor should realize it, and by his actions, the members of the group should know it.

Summary

There are three main areas with which any supervisor is concerned:

1. The specific duties concerned with project direction and administration.
2. Communication and interchange of information within the company in two dimensions:
   a. Vertically, with the supervisor's superiors and subordinates.
   b. With related engineering groups or service groups supporting the activity.
3. Group leadership, or the art of directing the activities of others by inspiration rather than perspiration.

The area of leadership is the most important. Leadership is essentially an art, which must be developed. Its practice is intimately connected with the characteristics and personality of the individual. An engineer can be developed into a good leader—hence, a good supervisor—but the necessary attributes must be inherent in the man from the start.

Finally, because the development of a supervisor is a long, and sometimes subtle, process, the transition period is the critical time, the time when the character of the man as a supervisor is formed.

ACKNOWLEDGEMENT: This article has been adapted from a paper which will appear in the 1957 *IRE Wescon Convention Record.*

Tips and Techniques

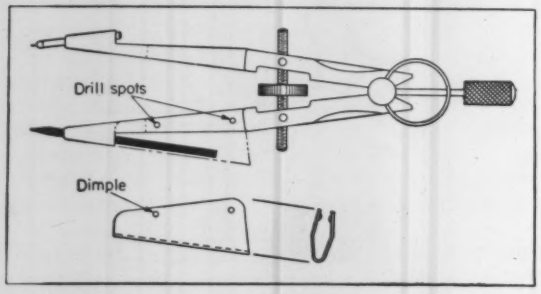
Squaring Numbers

Multidigit numbers, with or without decimals, can be squared readily by remembering the equation $A^2 = (A + X)(A - X) + X^2$. In this case X is any number that, when added to or subtracted from A, leaves a convenient round number. For instance, to square 6.25, $X = 0.25$; $(6.25)^2 = (6.50)(6) + 0.0625 = 39 + 0.0625 = 39.0625$. For an example where X is added to A, the square of $196 = (196 + 4)(196 - 4) + (4)^2 = (200)(192) + 16 = 38{,}400 + 16 = 38{,}416$. — M. L. BAXTER, *Montreal.*

Compass-Lead Guard

Long compass lead, extending beyond the holder opposite from the drawing end, can be protected from breakage during normal use. A small lightweight guard can be easily made from a piece of steel.

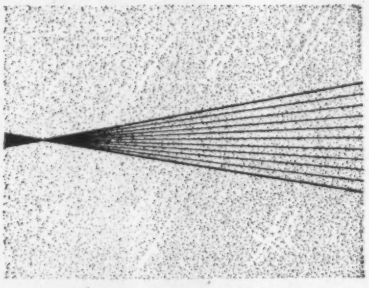
First, make a cardboard template to determine proper size and shape for the particular compass. Then cut the metal to this shape. Form to approximate shape shown, so that it will snap tightly into 1/16-in. diam drill spots. These drill spots should be carefully located in one leg of compass, two on each side. Do not locate over slotted section as this may weaken clamp. Caution should be taken in drilling not to drill spot any larger than necessary.



In most cases, the taper of a drill bit is enough. The guard should be dimpled with a 1/16-in. diam nail or similar object, with the end rounded. Wedge a piece of soft wood between legs of guard to absorb the shock. Changing of leads will be greatly reduced as the guard permits using a longer piece.—ROBERT JOHNSON, *Racine, Wis.*

Interpolating Device

A simple device can be readily constructed to aid in interpolating between values on charts or graphs. The aid is a transparent plastic shield with lines drawn from ten equally spaced points and converging on a common point about 3½ in. away. A line spacing of ⅛ in. is convenient for most



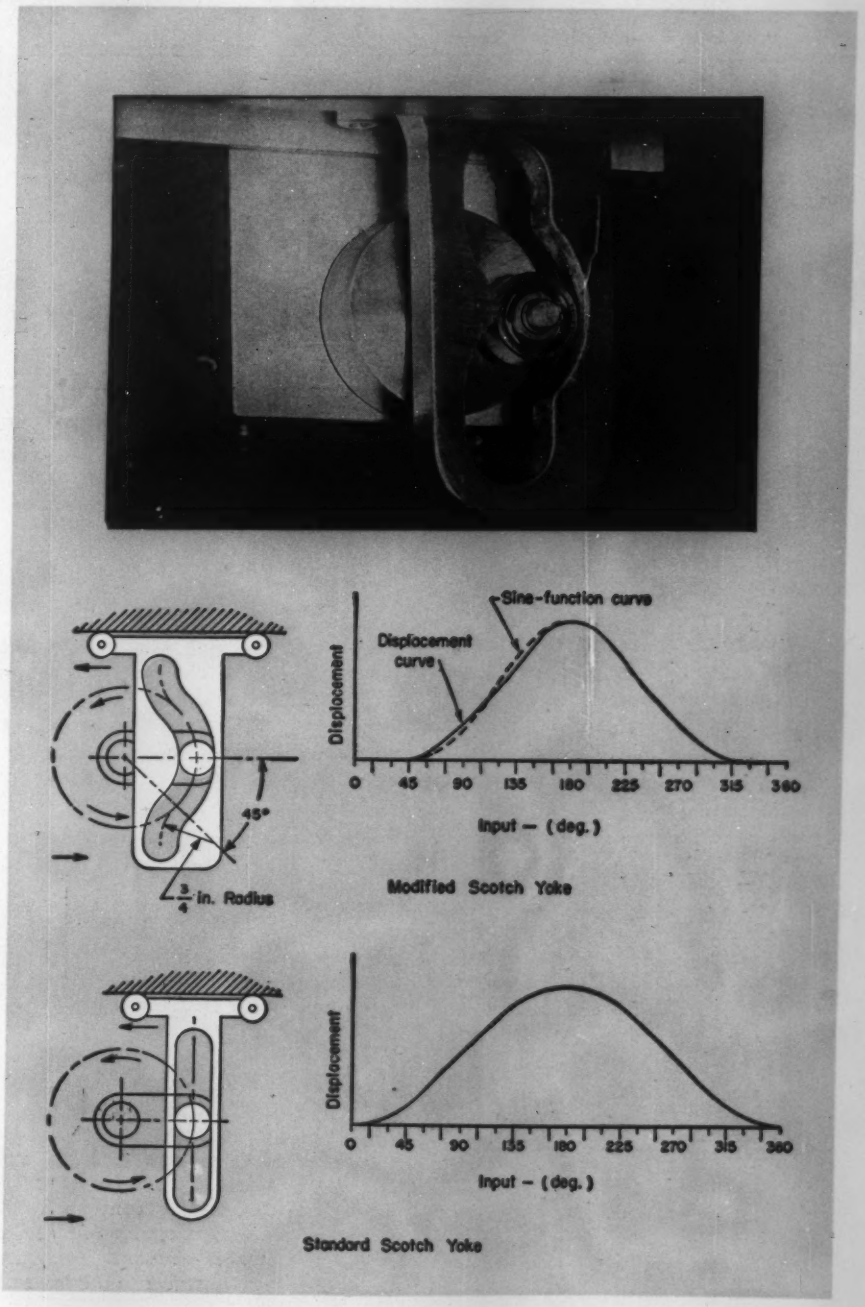
uses. To use, place the outer lines on the aid under the points to be interpolated between. The center line on the aid is arranged perpendicular to the line of measurement, dividing the space between the two given points into ten equal parts. A similar aid can be constructed for logarithmic charts by using a logarithmic line spacing rather than equal spaces.—HARRY D. BALLARD, *design engineer, Cessna Aircraft Co., Wichita, Kansas*

scanning the field for *ideas*

Modified Scotch-Yoke

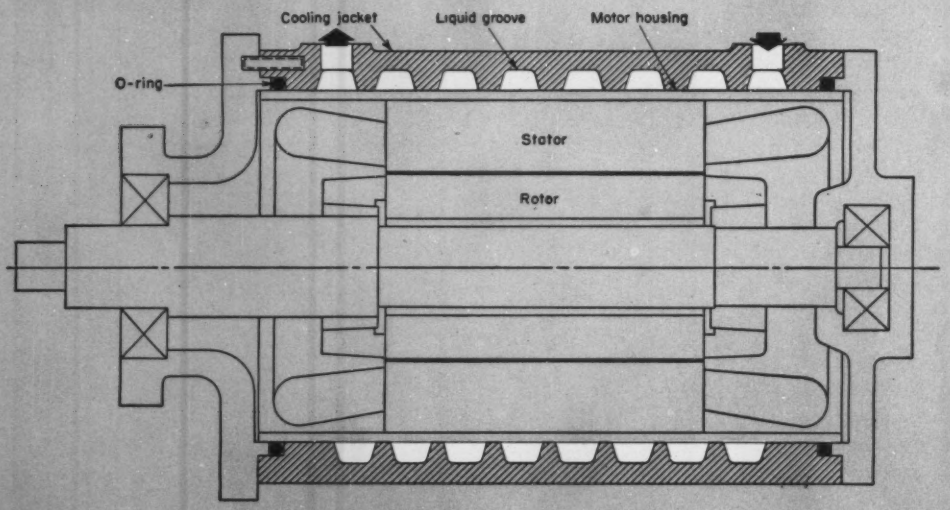
mechanism for rotary-to-linear conversion of motion produces a dwell period and a near sine-function output from a constant angular input. The compact design can be produced without cam machinery and, for a given output, is smaller than an equivalent cam and follower. The modification, reported by Glen R. Heidler, was developed as part of a research project at Massachusetts Institute of Technology, jointly supported by the Army, Navy, and Air Force.

The modified Scotch Yoke combines a 90-degree dwell period with a displacement curve that compares favorably with a sine function over the same angular distance. The dwell period may vary, but to maintain a smooth output displacement, it should not exceed 90 degrees.

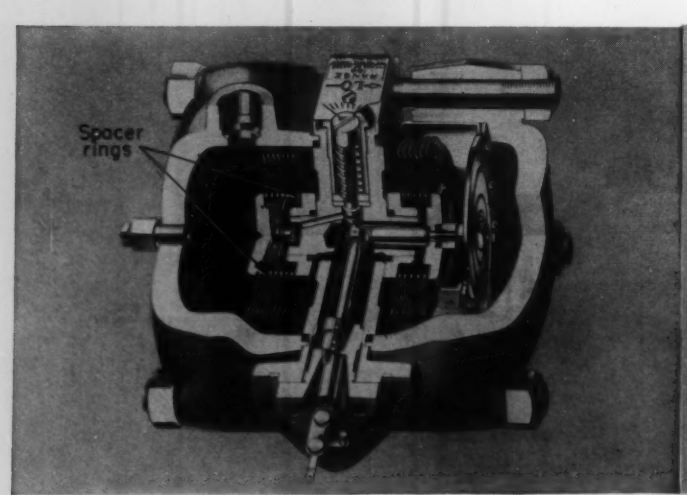


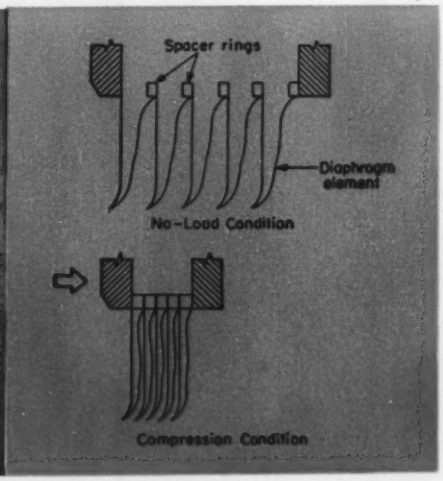
ideas

Cast-spiral fluid passage improves efficiency of jacket-type heat exchanger and offers cost advantages in production and assembly. In a high-speed electric motor designed by Standard Electric Tool Co., a helical groove is cast on the inner surface of the cooling jacket. Liquid, pumped through the helical groove at high velocities, eliminates heat pockets and assures continuous replacement of coolant. The cast fluid-path construction provides a large heat-transfer surface area and reduces machining operations to a minimum.



Protection from distortion caused by excessive compression forces in spring-type devices is provided by metal spacers. In a bellows, each pair of diaphragm elements is welded to a flat spacing ring at the inner circumference. The diaphragm element pairs are joined at the outer circumference to form the complete bellows. Under extreme compression loads, the spacer rings contact each other to form a solid stack, preventing damage to the diaphragm elements. The design was developed by the Foxboro Co.





DESIGN MANUAL

Selection and Application of

Dynamic SEALS AND PACKINGS

By
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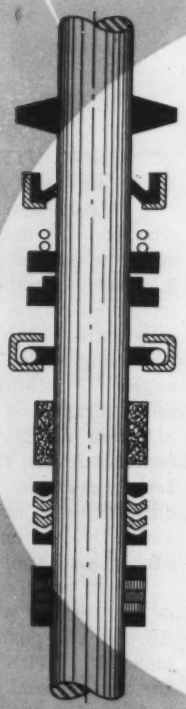
Machine Design



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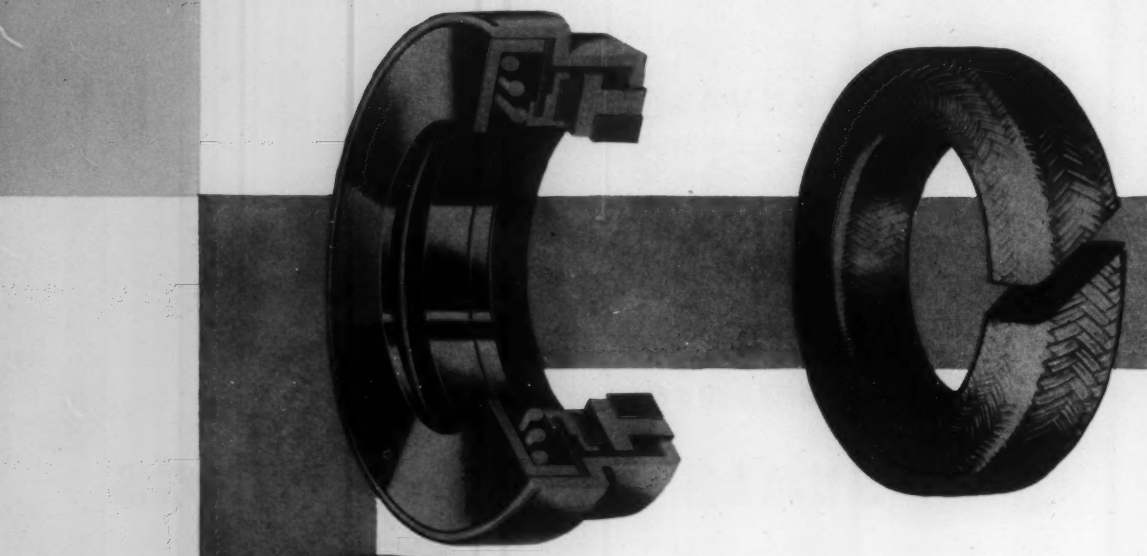
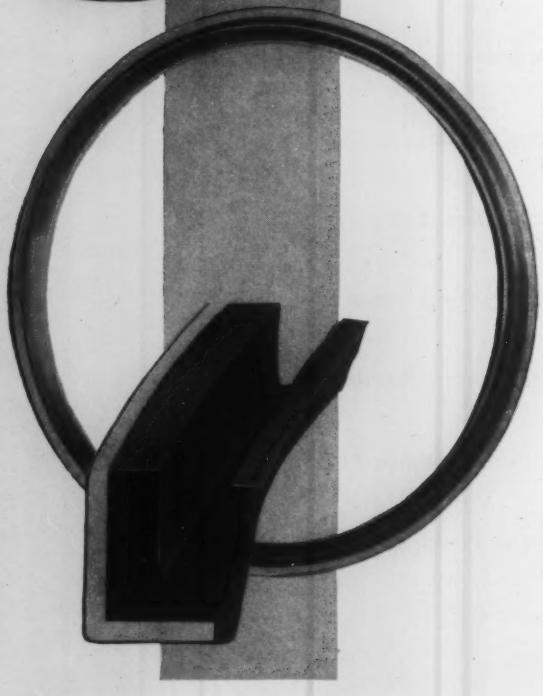
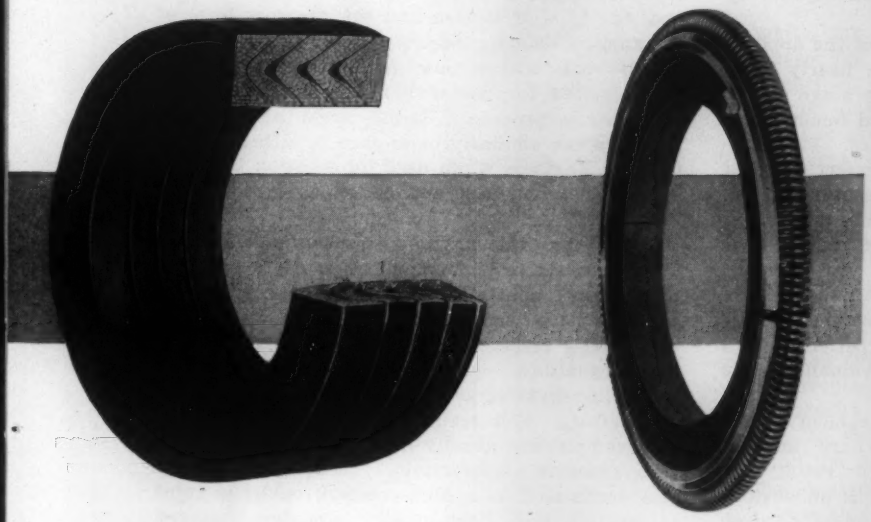




DYNAMIC SEALS AND

CONFRONTED with a dynamic-sealing problem—one where fluid leakage between relatively moving parts must be controlled or stopped—the designer has available either of two common techniques: 1. Controlled clearance. 2. Positive contact. Representative of the controlled-clearance seal are throttling bushings and labyrinths, both operating by virtue of fluid-throttling action in narrow annular or radial passages. Frictionless and virtually insensitive to temperature and speed, clearance seals are chiefly effective as devices for limiting leakage to acceptable levels, rather than stopping it completely. Long used in steam-turbine installations, the clearance seal now finds use in gas-turbine engines and is widely employed as auxiliary protection in contact-seal applications.

Where positive containment of liquids or gases is required, or where the seal area is continuously flooded, the positive-contact seal is usually recommended. With proper selection and application, the contact seal can be relied upon to provide zero leakage for almost any liquid or gas. However, because it is sensitive to speed, temperature and



Fluid tightness and service life—the principal measures of seal performance — meet design objectives when seal limitations are accurately matched to service demands. Prediction, not measurement, however, represents the first-order concern of the designer. Basic to prediction of seal performance is study of these service conditions:

- **Pressure**
- **Speed**
- **Temperature**
- **Fluid characteristics**

This article shows how these factors are analyzed to provide guides to selection and application of dynamic sealing methods.

PACKINGS

. . . a comprehensive survey of ways and means for positive-contact sealing of moving shafts

pressure, improper application of the contact seal usually results in early failure.

As a guide to the selection and application of positive-contact seals, this article surveys representative types applicable to rotating and reciprocating shafts. In many cases, seals illustrated are off-the-shelf items. In other instances, they were developed to serve the special demands of a particular application. Custom design is a service offered by many major seal manufacturers and, for the particularly difficult application, probably offers the best alternative to the designer.

Seal Performance: Operational effectiveness of a dynamic-seal installation is measured by a simple standard: If it doesn't leak too much, too soon, it's a good seal. To the designer of the installation, this favorable judgment means that the conditions of the application have been correctly gaged and matched to the performance capabilities of the seal. The complicated interdependence of the seal and service factors makes the matching problem a difficult one.

Obviously, a seal or packing can be expected to function properly when it is operated within its design limitations. Certain conditions of an application are known with reasonable accuracy—speed, fluid pressure, and medium characteristics are examples. Other service factors—for example, shaft deflection, runout, and endplay—can be estimated with some realism. Admittedly, these par-

ticular quantities can change substantially during the service life of the seal.

Beyond the predictable conditions of the application, there remain several that are nearly indeterminate, at least during the design stage of the project. An example is the stabilized temperature that exists at the seal rubbing surface. This temperature, which has a first-order effect on seal life, depends not only on the temperature of the sealed fluid, but also on rubbing-surface lubrication and finish, seal contact pressure, and rate of heat transfer to and from the seal area. An extensive development and field-test program is often required before all major and minor service factors can be uncovered. Obviously, experience with similar installations provides an invaluable guide during the early project stages.

Complicating the seal-selection problem is the fact that many operating factors are interdependent. The performance-velocity rating assigned by many seal manufacturers is an obvious example. In general, allowable speed of a given seal type decreases as the pressure of the contained fluid increases. This, however, is not the whole story. Experience shows that allowable speed depends not only on pressure, but also on temperature, shaft finish, deflection, whip and endplay, and upon the actual lubrication that reaches the seal. These conditions are normally the responsibility of the seal user and are not controlled by the seal manufacturer.

Seal Selection: In following sections of this article, seals are grouped in the following categories:

1. Felt seals and wipers.
2. Oil-retainer or radial seals.
3. Mechanical or axial seals.
4. Floating-ring seals.
5. Compression packings.
6. Molded synthetic packings and O-rings.
7. Leather packings.

It is possible to block out rough areas of use for these typical positive-contact seals. To this end, the type of motion and the pressure level of the application are good criteria.

Felt seals and wipers, for example, are generally suited for use with shafts that either rotate or reciprocate. Radial seals and molded packings can similarly be applied to either type of motion. O-rings, while used on occasion in rotating service, find best application with reciprocating shafts.

The design of conventional mechanical and floating-ring seals restricts application of these types to rotating shafts. Although compression-type packings have been applied to rotating shafts, they are usually reserved for high-pressure reciprocating installations.

The line dividing low and high-pressure service is not distinct. Felt seals and ordinary radial seals, for example, are usually restricted to use at near-zero pressure differentials. Therefore, a radial seal designated as a high-pressure model is rated at, say 150 psi. Even at such a modest pressure, a radial seal of this rating may be confined to use in low-speed service.

In the next higher pressure range, the floating-ring seal is generally considered to withstand 20-30 psi per ring. By stacking rings, which is a conventional procedure, the designer extends the pressure capability of this type to several hundred pounds per square inch.

The mechanical seal is provided in balanced models rated to 1000 psi or higher. As for most seal types, allowable speed of the mechanical seal usually decreases with increasing pressure.

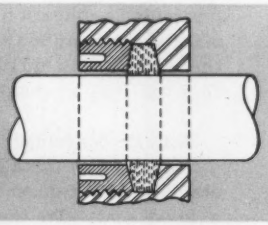
Pressures in the 10,000-100,000 psi range have been successfully contained by compression-type and molded packings. Although one of the oldest packing forms, and despite the disadvantages of high friction and rapid shaft wear, the compression seal still finds extensive use where pressures are very high or where sealed shaft diameters are large.

DYNAMIC SEALS

Classification of sealing devices into the principal categories of *seals* and *packings* is, to some extent, an arbitrary process. Although attempts have been made to define a particular sealing method on the basis of function, inconsistencies quite often appear. On the basis of sealing action, for example, parallels can be drawn between the operation of V-rings, which are usually classed as packings, and the operating characteristics of radial seals.

In this article, the classification system followed by the majority of manufacturers of both sealing methods has been employed. This section on seals reviews the basic seal types, including felt seals, radial seals, mechanical seals and floating-ring seals.

Felt Seals



As an economical material for retaining shaft bearing lubricants and for blocking entry of abrasives, moisture or fumes, felt has several attractive physical characteristics: 1. High liquid-absorbing capacity. 2. Low coefficient of friction. 3. Long-lasting resiliency. Operating-temperature limits of the

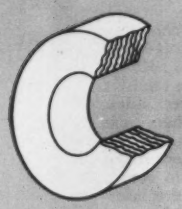


Fig. 1—Durable and economical, plain-felt seals are cut from standard SAE felt grades. Operating-temperature limits are in the −60 to 250 F range; maximum allowable rubbing speed is approximately 2000 fpm. Impregnation of the basic felt with petroleum or graphite compounds increases resistance to pressurized lubricants and low-viscosity liquids.

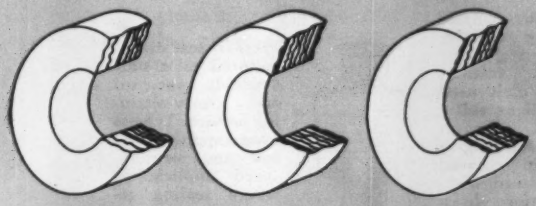


Fig. 2—Laminated felt seals combine one or more grades of felt with impervious elastomer layers. The sandwich construction stops leakage of low-viscosity liquids, combines functions of oil retainer, sealing washer, and dust excluder.

basic seal felts are approximately −60 to 250 F. Allowable rubbing-surface speeds are, except for special felt grades, restricted to about 2000 rpm. Because of its resiliency, the felt seal maintains nearly constant sealing pressure regardless of seal wear, shaft end play, or misalignment within normal limits.

Classification: Felt seals are manufactured in two general types:

1. Plain felt seals.
2. Laminated felt seals.

To meet special requirements, either style can be impregnated with one of several materials. Compounds of paraffin, petrolatum, or micronized graphite, for example, increase the resistance of the basic felt to water and mud and improve its resistance to pressurized lubricants. In most applications, however, presaturation of the basic felt with oil or grease of slightly higher viscosity than that of the sealed medium has been found adequate.

PLAIN FELT SEALS: Fabricated from standard grades of felt, plain felt seals, Fig. 1, are precision-cut washers, usually presaturated with lubricant. Where bearing temperatures and shaft speeds are within specified limits, the plain felt seal is effective and durable, usually requiring replacement only when the machine is overhauled. Plain felt is not recommended for sealing oils of extremely low viscosity, or for retaining pressurized lubricants. In such cases, either an impregnated felt seal or the laminated type should be considered.

The presaturated plain seal ensures positive bearing protection by serving as a reservoir for excess lubricant, making it available as needed. Where dry running occurs, the seal usually polishes rather than scores the shaft.

LAMINATED FELT SEALS: Several varieties of the laminated felt seal are available, Fig. 2. In each case, impervious layers of oil-resistant elastomer effectively stop leakage of low-viscosity liquids through the felt. Advantage of the sandwich construction is that it permits use of two or more felt grades in one seal, one grade for oil retention, a second grade for dust exclusion, for example. Where application requirements are unusually severe, multiple-dam construction can be employed. High-pressure laminated sheeting, comprising multiple layers of felt impregnated with polymeric compounds, is also available. Because of the high ratio of impregnant to felt, chemical resistance of such seal materials follows those of the polymer used.

Selection and Application: Recommended SAE felt grades, dimensional tolerances, and housing

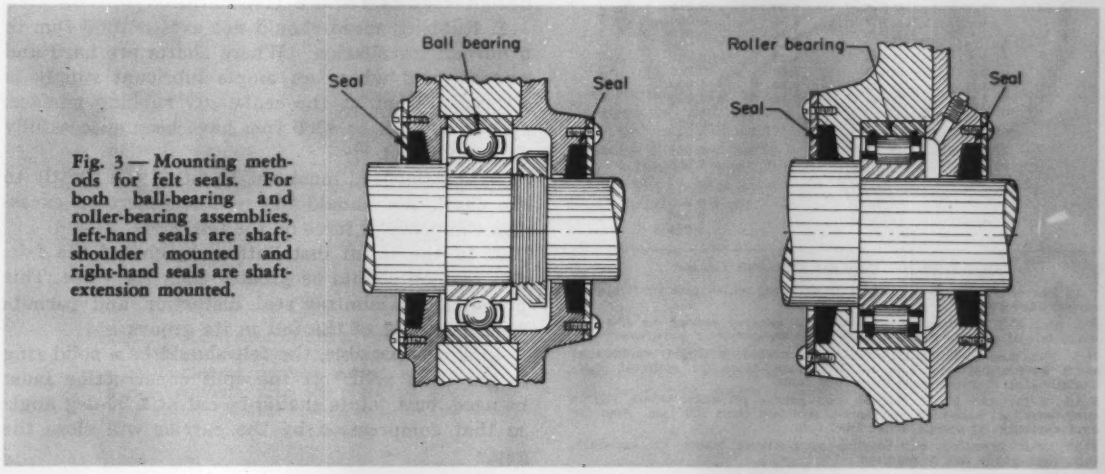


Fig. 3 — Mounting methods for felt seals. For both ball-bearing and roller-bearing assemblies, left-hand seals are shaft-shoulder mounted and right-hand seals are shaft-extension mounted.

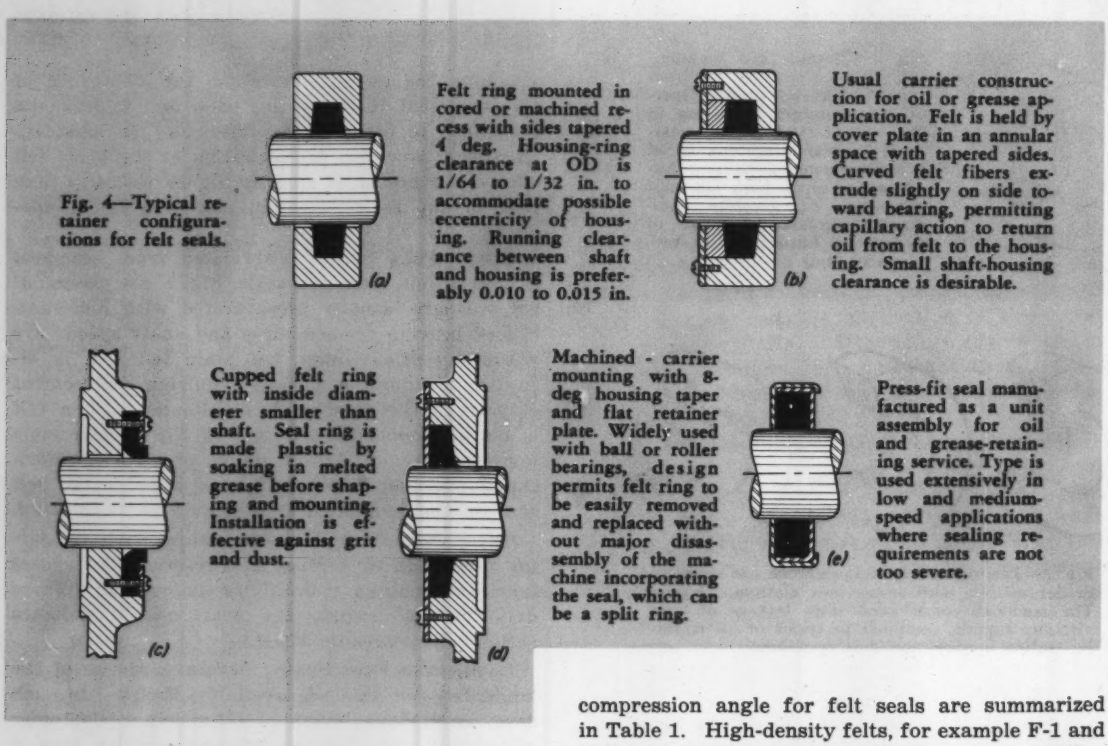


Fig. 4—Typical retainer configurations for felt seals.
(a)
Felt ring mounted in cored or machined recess with sides tapered 4 deg. Housing-ring clearance at OD is 1/64 to 1/32 in. to accommodate possible eccentricity of housing. Running clearance between shaft and housing is preferably 0.010 to 0.015 in.
(b)
Usual carrier construction for oil or grease application. Felt is held by cover plate in an annular space with tapered sides. Curved felt fibers extrude slightly on side toward bearing, permitting capillary action to return oil from felt to the housing. Small shaft-housing clearance is desirable.
(c)
Cupped felt ring with inside diameter smaller than shaft. Seal ring is made plastic by soaking in melted grease before shaping and mounting. Installation is effective against grit and dust.
(d)
Machined - carrier mounting with 8-deg housing taper and flat retainer plate. Widely used with ball or roller bearings, design permits felt ring to be easily removed and replaced without major disassembly of the machine incorporating the seal, which can be a split ring.
(e)
Press-fit seal manufactured as a unit assembly for oil and grease-retaining service. Type is used extensively in low and medium-speed applications where sealing requirements are not too severe.

Table 1—Felt-Seal Application Data

SAE Felt Grade*	Shaft Diam (in.)	Seal Dimensions ID (in.)	Seal Dimensions OD (in.)	Seal Dimensions Thickness (in.)	Housing Angle (deg)
F-1	0.5	0.495	1.00	0.187	4
F-2	1.0	0.995	1.50	0.250	4
F-3	1.5	1.495	2.25	0.375	4
	2.0	1.995	2.75	0.500	4
	2.5	2.495	3.25	0.500	4
	3.0	2.995	4.00	0.500	4
	3.5	3.495	4.50	0.750	4
	4.0	3.995	5.00	0.750	4
F-5	0.5	0.485	1.00	0.250	5
F-6	1.0	0.985	1.50	0.375	5
F-7	1.5	1.485	2.25	0.500	5
	2.0	1.985	2.75	0.500	5
	2.5	2.485	3.25	0.500	5
	3.0	2.985	4.00	0.750	5
	3.5	3.485	4.50	0.750	5
	4.0	3.985	5.00	1.000	5
F-10	0.5	0.469	1.00	0.375	7
F-11	1.0	0.969	1.50	0.500	7
F-13	1.5	1.469	2.25	0.500	7
F-15	2.0	1.969	2.75	0.500	7
	2.5	2.469	3.25	0.750	7
	3.0	2.969	4.00	0.750	7
	3.5	3.469	4.50	1.000	7
	4.0	3.969	5.00	1.000	7
F-50	..	....	...	0.050	..
	..	....	...	0.055	..
	..	....	...	0.060	..
	..	.. .	..	0.065	..
	..	....	...	0.070	..
	..	....	...	0.075	..
	..	....	...	0.080	..
	..	...	...	0.085	..

Recommended Uses for SAE Felt Grades

F-1: For oil retention where felt is not compressed and shaft speeds exceed 1000 fpm.

F-2 and F-3: Recommended for same general service as F-1 but when felt of slightly lower quality is satisfactory.

F-5, F-6, and F-7: Used for oil and grease retaining washers at shaft speeds between 750 and 1000 fpm. Also for difficult dust-excluding service at speeds over 1000 fpm.

F-10, F-11, and F-12: For oil and grease retention where felt is compressed at assembly and speeds are less than 750 fpm. Also for dust exclusion at speeds under 1000 fpm.

F-50: For precision ball-bearing applications where an accurate, thin, high-grade felt is required.

compression angle for felt seals are summarized in Table 1. High-density felts, for example F-1 and F-2, are specified for difficult oil or grease-sealing applications where rubbing speeds exceed 1000 fpm. Where the seal functions as a dust excluder, or where it serves as a oil retainer at lower shaft speeds, (less than 750 fpm) one of the lower-density felts, for example, F-11 or F-13, can be specified.

Two common mounting methods employed with felt seals are: 1. Shaft-shoulder mounting, where the seal ID equals that of the bearing-locating shoulder. 2. Shaft-extension mounting, where the seal is sized to the shaft diameter that just permits passage of a bearing-retaining nut. These techniques are illustrated in Fig. 3. A survey of common felt-seal retaining methods is given in Fig. 4.

For effective felt-seal operation, the following design factors require consideration:

1. Rubbing speed should not exceed 2000 fpm in a normal installation. Where shafts are hard and smooth, and where an ample lubricant supply is always present at the seal-shaft rubbing surface, speeds as high as 4000 fpm have been successfully accommodated.

2. The felt seal must not be fitted too tightly to the shaft, nor should the retainer exert an excessive compressive force on the felt.

3. In the usual installation, height of the felt-ring section should be greater than its width. This proportion minimizes seal distortion and permits firm clamping of the felt in its groove.

4. Where possible, the felt should be a solid ring rather than split. If the split construction must be used, butt joints should be cut at a 30-deg angle so that compression by the carrier will close the gap.

Radial Seals

The designation *oil seal* has been generally accepted to mean a positive-contact seal that exerts radial sealing pressure over on annular shaft area. In such service, the oil seal usually has a dual purpose: 1. It blocks leakage of lubricant. 2. It prevents entry of foreign matter. Although the majority of applications involve the sealing of an unpressurized lubricant—grease or oil, for example—the so-called oil seal finds effective use with a wide variety of gases and liquids. For this reason, the *radial seal* designation perhaps more accurately describes the type.

The rotating-shaft application of the radial seal is most common. However, the radial seal is also used where shaft motion is oscillating or reciprocating. Generally distinguished as an individual type, the wiper ring is specially designed to exclude foreign matter in reciprocating or rotating installations. Where the application requires that the seal rotate with the shaft, the external seal is available. Standard nomenclature for typical radial seals with garter springs to augment pressure against shaft is given in Fig. 5.

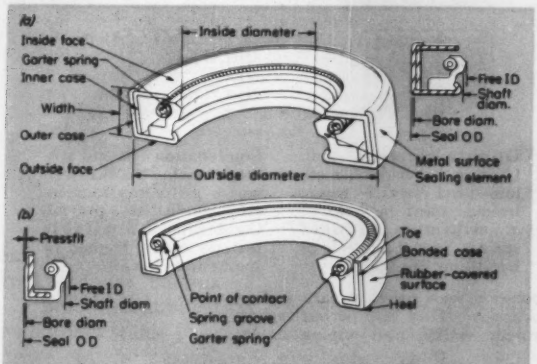
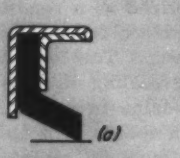


Fig. 5—SAE nomenclature for metal-cased radial seal, *a*, and bonded radial seal, *b*.

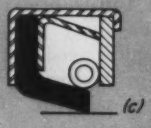
Radial-Seal Classification: Because of the variety of applications, the radial seal is manufactured in a profusion of types and sizes. Categories are generally established for: 1. Cased seals, Fig. 6, wherein the leather or synthetic sealing element is retained in a precision-manufactured metal case. 2. Bonded seals, Fig. 7, wherein the synthetic sealing element is permanently bonded to a flat washer or to a formed-metal case. Seals of both categories can be provided with spring-tension elements, either garter-spring or finger type, for use where either shaft speed or eccentricity demand higher unit sealing pressures. Use of the bonded-type seal is often recommended where operating conditions require increased seal flexibility, or where installation space is limited by external design requirements.

Dual-element or combination seals, Fig. 8, are available for unusually severe service, or where liquids are present on both sides of the seal. Other combination seals provide a sealing action in one



Flange-type seal with leather or synthetic element. Used primarily to seal against light dust or to retain heavy grease, this type is not suitable for sealing low-viscosity oil.

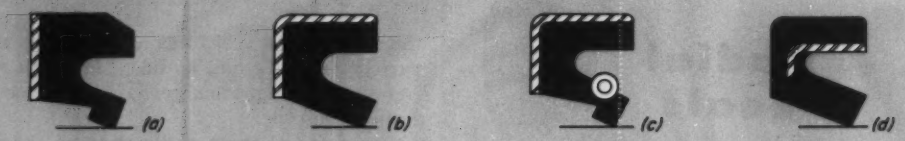
Washer-type leather seal. Adapted for sealing grease or viscous fluid where use of a spring-loaded seal is not practicable. Often combined with a spring-loaded seal in a dual element.



All-purpose spring-loaded seal with leather or synthetic element. Pressure range of synthetic type is 0-10 psi; leather type withstands 0-15 psi.

External seal. Used where speeds are in low range and seal is to be pressed on the shaft. Leather element is suitable for sealing grease or viscous fluids; synthetic element requires flooded lubrication and can be used with fluids of low viscosity.

Fig. 6—Metal-encased radial seals, shown here in typical single-element styles, are available with leather or synthetic-rubber elements. As a rule, synthetic seals are preferred where rubbing speeds exceed 2000 fpm or where media temperatures are higher than about 200 F. In contrast to the leather element, which operates satisfactorily with little or no lubrication, the synthetic type requires continuous lubrication.



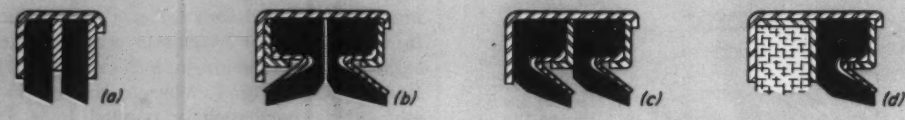
Washer seal, limited-contact lip. Designed for press fitting in a straight bore. Limited rubbing-contact area leads to low friction-torque drag on the shaft.

Bonded case seal, straight lip. For retaining fluid in rotating-shaft installations. Unit is pressed into a straight bore; no groove is required.

Bonded case seal, limited-contact lip plus garter spring. Garter spring accommodates shaft eccentricity, provides initial tension before medium comes up to pressure.

Embeded-case seal. Synthetic cover on outside of seal compensates for possible unequal expansions of housing and seal. Straight lip suitable for most applications.

Fig. 7—Bonded single-element radial seals, available in conventional or external styles, are recommended for use where space or flexibility requirements are difficult to satisfy by use of the metal-encased type. Because the sealing element is synthetic, lubrication must be supplied continuously to the rubbing area. Addition of garter or finger spring to basic seal increases allowable surface-speed.



Tandem-washer leather seal. Arrangement of elements permits space between washers to be grease packed when necessary. Leather washers, however, operate satisfactorily with intermittent lubrication.

Dual-opposed seal. Applicable to service where liquids are present on both sides of seal. Maximum recommended surface speed is 1000 fpm.

Double-element seal. Used in heavy-duty, medium-speed service where leakage must be held to a minimum. Finger springs can be steel or beryllium copper.

Combination felt and synthetic seal. Works well where gritty environmental conditions prevail. Combinations available include either leather or synthetic elements.

Fig. 8—Double-element or combination seals provide extra sealing action for unusually severe applications. They also permit separation of two fluid media, or provide sealing plus wiping action.

direction, plus a wiping action in the reverse direction.

Seal Selection: Design of the radial seal often represents a compromise. Lip pressure must be high enough to prevent leakage, but still light enough to permit formation of a thin lubricating film between the seal lip and the shaft surface. Source of the lubricating film—which need not be oil—can be the sealed medium, or it can be established by a lubricant-saturated seal lip. Obviously, conditions of the service will determine both effectiveness and life of the radial seal. Most important of these conditions are:

1. Shaft speed, interpreted as rubbing velocity.
2. Temperature to which the seal is exposed.
3. Pressure exerted on the seal.
4. Condition of the shaft surface.
5. Nature of the sealed medium.

These factors are interdependent. Although the radial seal may perform satisfactorily where conditions are particularly severe in one or even several categories, it may fail completely if all factors are simultaneously unfavorable. Relationship of these operating conditions to the seal application and selection problem is outlined in the following sections.

RUBBING SPEED: Allowable rubbing speed for the radial seal depends not only on temperature and pressure, but also on the seal design. Tolerances on shaft finish, eccentricity, and end play are usually tightened when speeds increase. Shaft eccentricity can be described as a condition where a point on the shaft surface follows an eccentric rather than circular path. This action leads to constant flexing of the sealing lip, assuming, of course, that the lip remains in contact with the eccentric shaft. At high speeds, it is unlikely that sealing contact is continuously maintained, and leakage can therefore be expected.

For speeds in the higher ranges, the spring-loaded radial seal is often recommended. Usual rubbing-speed limit for leather seals is about 2000 fpm; synthetic seals are often rated to 4000 fpm or higher, depending upon the pressure.

FLUID PRESSURE: Standard radial seals are not usually designed to contain fluids under pressure. Therefore unsuspected pressure sources sometimes lead to early seal failure. For example, pressure can build up to substantial levels in unvented gear boxes, or in installations where vents are clogged with dirt or paint. Pumping action of a bearing also increases pressure on the seal lip. In such cases, the space between the seal and the bearing

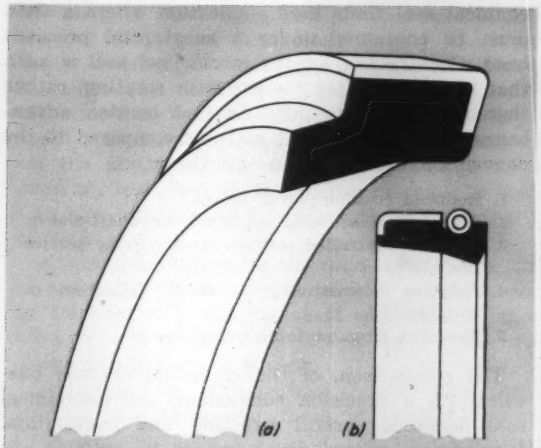


Fig. 9—Pressure range of the conventional radial seal is usually restricted to about 0-15 psi, particularly in rotary applications. In this high-pressure seal, pressure exerted at the open end of the lip is almost completely supported by the metal shell, permitting use of the seal at pressures to 150 psi. Shaft-speed limit of model without spring, *a*, is 2500 fpm; spring-loaded seal, *b*, accommodates speeds as high as 4000 fpm. Use in applications where both speed and pressure are high is not recommended.

can be vented back to the main reservoir to prevent pressure buildup.

Where the application demands use of a radial seal under high pressure, say, in the 100-150 psi range, special designs are available, Fig. 9. Such high-pressure radial seals are usually restricted to relatively low-speed applications.

TEMPERATURE LIMITS: Heat at the seal lip is generated by rubbing friction, bearing friction, oil agitation, and heat conducted from other parts of the machinery. Molded synthetic elements are usually recommended when temperatures range from about −40 to 300 F under continuous operation. Upper limit on leather sealing elements is in the 250 F range.

SHAFT-SURFACE REQUIREMENTS: Shaft hardness, smoothness and material are factors that are considered to be seal-application problems. Usual recommendation for shaft hardness is at least Rockwell C 50. If the shaft is one of the soft metals, brass or aluminum, for example, it is advisable to press a hardened steel ring on the shaft to serve as a seal running surface. Hard chrome plate, if of adequate thickness and quality, can also be employed.

Maximum seal efficiency and life are obtained with a finely finished shaft surface, usually in the 10 to 20 microinch range. Direction of finishing marks and spiral lead are important, and polished or ground finishes with concentric marks are preferred. When a finish lead is present, it should be in the direction that guides the sealed medium inward.

SEAL MATERIALS: Because leather is absorbent, it provides a self-lubricating seal that operates for long periods with little or no auxiliary lubrication. In addition, leather is less sensitive to shaft finish than synthetic-rubber compounds, working satisfactorily even when the shaft or bore is rusty. These characteristics particularly recommend the leather seal for use where maintenance is inexpert or neglected. Limitations on shaft speed and temperature must, or course, be considered in the application.

Synthetic-rubber seal materials are specified when rubbing speeds exceed about 2000 fpm, when temperatures are high, and when a substantial pressure head is present. The synthetics can be compounded to be impervious to oil, water, mild acids and alkalines. As compared to the leather types, the synthetic seals withstand shaft runout and eccentricity with less chance of leakage. Lubrication must always be provided for synthetic seals, and shaft finish must be finer.

DRY RUNNING: It is not unusual for radial seals to be required to run for considerable periods of time without lubrication. For example, five minutes or more of operation may be required before oil reaches an engine crankshaft seal. Grease seals very often get no lubrication at all, but simply act to exclude dirt. It is important that such seals withstand dry running without wearing out or tearing, and in some cases without squealing. Naturally dry-running ability should not be demanded from a seal if not absolutely essential to the application. Almost without exception, leather seals are recommended for such situations.

At certain speeds, stick-slip of the seal on the shaft may have the same frequency as the natural resonance of the seal. At resonant speed, the resonating seal is extremely noisy, torque increases sharply, considerable wear occurs on the sealing lip.

LEAKAGE: Leakage for synthetic seals is usually lower than for leather seals, reaching near zero in many applications. About 80 per cent of synthetic seals leak perhaps 0.002 gm per hr, or about one drop every 11 hours. This is hardly enough to measure and is seldom troublesome in service. About 15 per cent leak between 0.002 and 0.1 gm per hr, a rate considered borderline in many applications. Few synthetic seals leak more than 0.1 gm per hr unless they are defective, assuming correct specification and installation.

By convention, the term *mechanical seal* designates a prefabricated or packaged assembly that

forms a running seal between flat, precision-finished surfaces. Except in a few special designs, sealing surfaces are oriented at right angles to the axis of shaft rotation. Direction of forces holding the sealing faces in contact is parallel to the shaft. This explains the alternate designation, *axial seal,* often applied to the type.

While differing in design detail, all mechanical seals make use of the following elements: 1. Rotating seal ring. 2. Stationary seal ring. 3. Spring-loading section for maintaining seal-face contact. 4. Static seals. These components are pointed out in the representative seal shown in Fig. 10.

Mechanical-Seal Advantages: In contrast to the radial seal, which is designed to operate under low to medium fluid-pressure differentials, the mechanical seal finds best application where a fluid must be contained under a substantial pressure head. Construction of the mechanical seal is such that it is best suited for use with rotating, rather than reciprocating shafts. In such service, advantages of the mechanical seal—as compared to the conventional stuffing box—are these:

1. Reduced friction-power losses.
2. Elimination of wear on shaft or shaft-sleeve.
3. Zero or controlled leakage over a long service life.
4. Relative insensitivity to shaft deflection or endplay.
5. Freedom from periodic maintenance.

The comparison, of course, is not entirely one-sided. As a precision component, the mechanical seal demands careful handling and installation. In addition, recent developments in stuffing-box packing have led to re-evaluation of this type as an economical and effective sealing method. Teflon and Kel-F, for example, have excellent self-lubricating qualities combined with high resistance to chemical attack. One claim made for a combination Teflon bearing and packing is that it seals gas pressures as high as 5000 psi with low coefficient of friction against the shaft. Where seal operating conditions are particularly severe—either with respect to temperature, or to the pressure-velocity relationship—the designer is required to analyze both the seal and the service before making a final choice.

Classification: As a packaged component, the mechanical seal is supplied in a wide variety of styles and performance ratings. Physically, four main seal categories are distinguished:

1. Stationary or rotating.
2. Balanced or unbalanced.
3. Inside or outside mounted.
4. Single or double element.

Service conditions dictating the use of mechan-

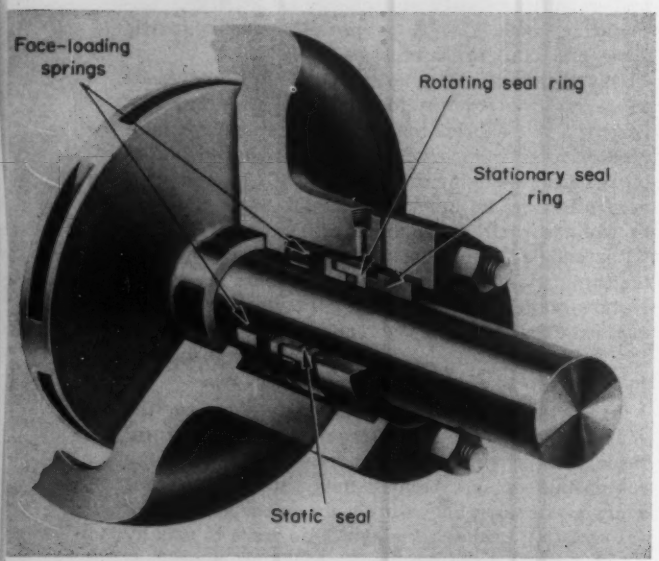


Fig. 10—Mechanical-seal construction details.

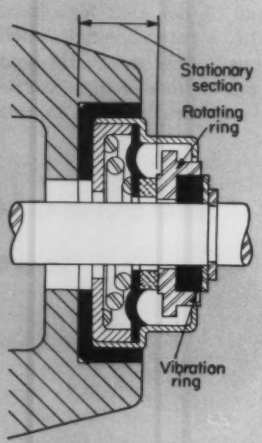
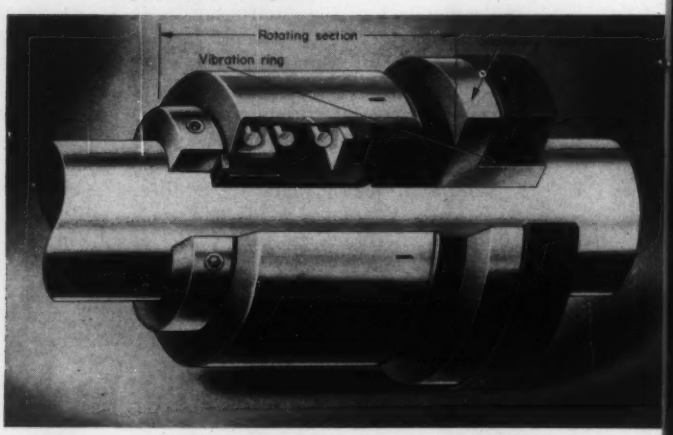


Fig. 11 — The spring-loading section of the stationary-type mechanical seal is fixed in the seal housing. To provide compensation for shaft run-out, the rotating seal ring in this design is resiliently supported by a synthetic ring. Flexible diaphragm connects housing with floating seal ring, eliminates need for static seals.

Fig. 12—Seat and vibration ring are fixed in the housing, and the spring-loading section rotates with the shaft in this representative rotating-type mechanical seal. Design shown is suitable for use at pressures to 150 psi, temperatures to 212 F, and speeds to 2000 fpm.



ical seals in these categories are discussed in subsequent sections of this article. Briefly, the arguments advanced for various types are as follows:

STATIONARY VS. ROTATING SEALS: Kinematically, the stationary seal, Fig. 11, is well suited to high-speed service, since centrifugal forces do not act on the spring-loading components. Design of a precisely machined shaft shoulder or collar to position the rotating ring is often the responsibility of the user.

A recommendation for the rotating seal, Fig. 12, is based on the relative ease with which it can be attached to a straight shaft section. A further advantage is its tendency to free itself from precipitated sediment or sludge.

BALANCED VS. UNBALANCED SEALS: The force holding mechanical-seal faces in contact results from the combined action of the spring-loading device plus the hydraulic pressure exerted by the medium behind the seal. Where pressures are high, reducing unit loading on the contact face below that of the medium improves both seal performance and life.

Area distribution in an unbalanced seal, Fig. 13*a*, shows that the total hydraulic pressure is allowed to act against the rear of the rotating seal ring. Unit pressure on the seal face therefore increases directly with the pressure of the sealed medium. Obviously, unit face pressure in the unbalanced design can increase to a level where no lubricating film remains between the sealing faces. At this point, seal faces would be destroyed.

Area distribution of a completely balanced seal

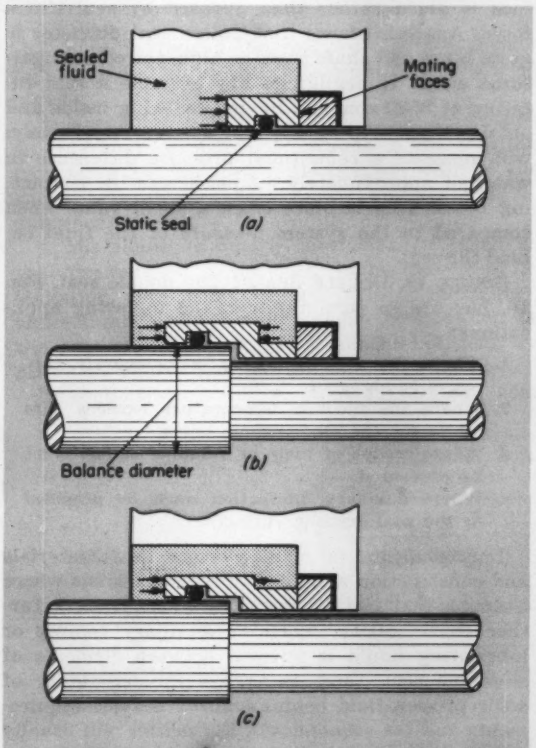
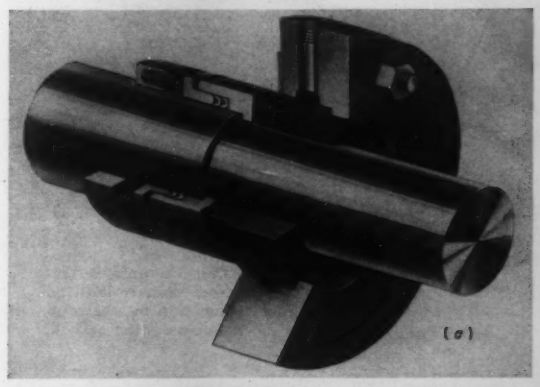
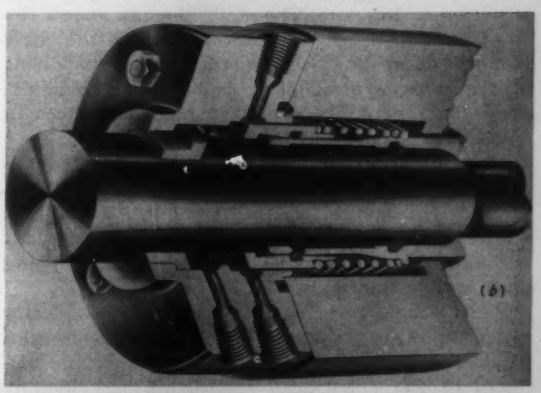
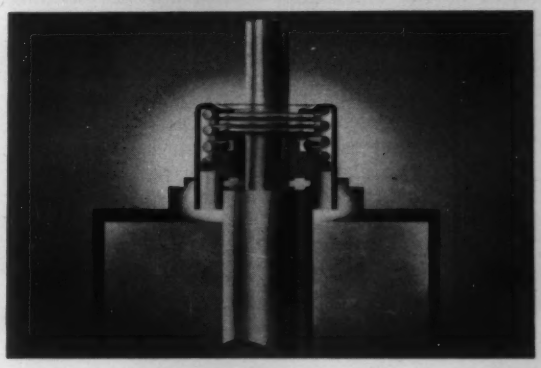


Fig. 13—Unbalanced and balanced mechanical-seal construction. Total hydraulic pressure in the unbalanced seal, *a*, acts on the rotating seal ring. Unit face pressures tend to become excessive at high fluid pressures. In the completely balanced model, *b*, the stepped-shaft allows fluid pressures to be cancelled. Seal spring alone holds faces in contact. Partially balanced seal, *c*, supplements spring pressure with a percentage of the sealed medium pressure.

Fig. 14—Typical balanced mechanical seals. Stepped-shaft model, *a*, which utilizes V-type static seals, is rated for pressures to 600 psi. Effect of stepped shaft is obtained by use of an integral sleeve in design *b*, which is available for pressures to 1000 psi. Bellows-type seal, *c*, is designed with the mean diameter of the seal-nose bearing surface equaling the mean diameter of the bellows. Variation in pressure of sealed medium therefore does not affect the thrust exerted by bellows and spring.







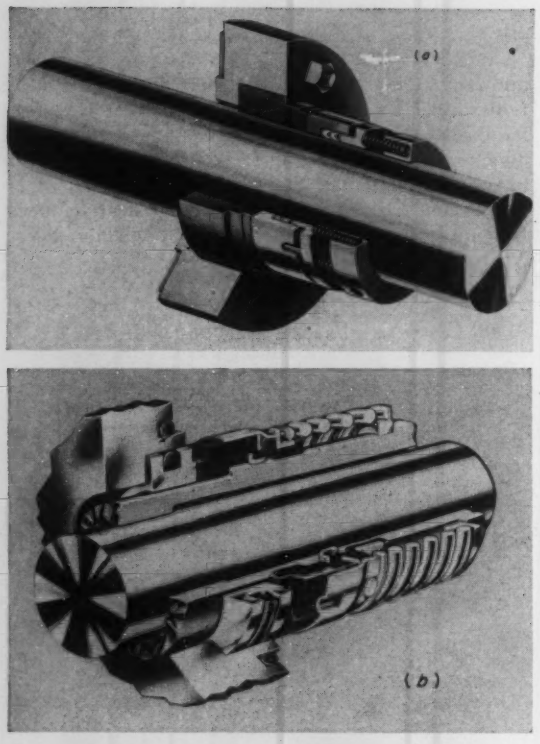


Fig. 15—Representative inside and outside-mounted mechanical seals. Outside unit, *a*, removes seal component parts from contact with an abrasive fluid. Mechanical protection to seal components is provided by the inside-mounted seal, *b*.

is shown in Fig. 13*b*. The stepped-shaft allows the rotating seal face to be positioned inside the shaft balance diameter. Because the axial component of the medium pressure is cancelled, the seal depends only upon its spring to hold seal faces in contact.

Most practical seals are designed to give the partial-balance effect shown in Fig. 13*c*. Here, a desired percentage of the medium pressure is allowed to supplement the spring pressure. This arrangement prevents the seal faces from popping open at high fluid pressures.

Recent tests have shown that rubbing velocity is as important as pressure in establishing service conditions that lead to selection of either the balanced or the unbalanced seal. While the dividing line between low-pressure and high-pressure applications is arbitrary, a quite generally accepted figure is 100 psi. The exact degree of balance required at higher pressure is set by the seal manufacturer after consideration of the pressure-velocity relationship, seal diameter, contact-face materials, and the characteristics of the fluid being sealed. Representative balanced seal designs are shown in Fig. 14.

INSIDE VS. OUTSIDE SEALS: Use of the outside-mounted seal, Fig. 15*a*, is often recommended where component parts of an inside unit (springs, pins, etc.) might be abraided by an abrasive or gritty fluid medium. A further consideration leading to use of the outside seal is a possible limit to housing space available for installation of an inside seal. However, the more widely used inside unit, Fig. 15*b*, usually permits design of a somewhat more compact seal installation.

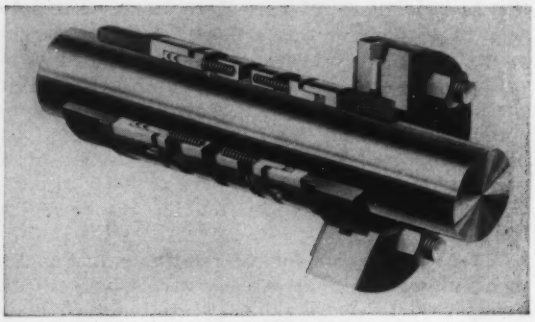


Fig. 16—Where service requirements are unusually severe, the double-seal installation is employed. Auxiliary liquid can be pumped between seal sections to lubricate the seal faces, prevent escape of toxic liquids, or to protect seal faces from an abrasive process fluid.

It has been claimed that a disadvantage of the outside seal is that leakage through the sealing face is aided rather than opposed by centrifugal force. Analysis shows that unless seal diameter is quite large and shaft speed is high, the centrifugal-force effect is negligible. For example a seal rotating at 3600 rpm and having seal-ring inside and outside diameters of 1¾ and 2.0 in., respectively, will generate a centrifugal pressure difference in water of approximately 3.2 psi across the contacting faces. This is qiute often a small value when compared to the system pressure of the fluid behind the seal.

SINGLE VS. DOUBLE SEALS: The double seal, Fig. 16, has design advantages in the following applications:

1. Where the sealed medium is excessively corrosive or abrasive.
2. Where the medium temperature exceeds safe limits for the seal organic parts.
3. Where escape of toxic or valuable liquids must be prevented.
4. Where auxiliary lubrication must be provided to the seal running surfaces.

Improvements in single-element seal materials and construction are steadily reducing areas where a double-seal installation is mandatory. As a further consideration, when an auxiliary cooling or lubricating liquid is pumped between elements of a double seal, there is always the possibility of some process-fluid contamination. Service requirements and the economics of the matter will usually dictate use of either single or double seal construction.

Selecting the Mechanical Seal: To the designer, solution of a mechanical-seal selection problem divides into two phases: 1. Choice of the physical seal configuration, whether inside or outside, single or double, etc. 2. Specification of the proper materials for seal components. Seldom are these se-

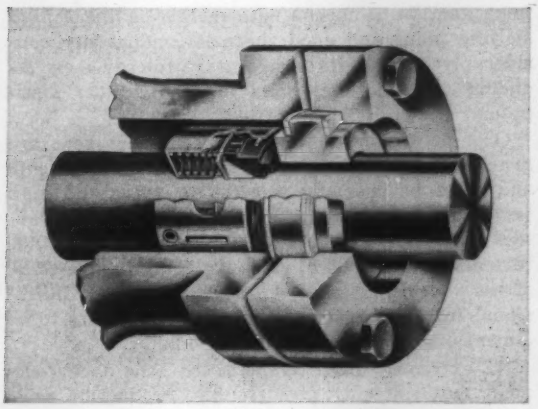


Fig. 17—Teflon static-seal element in this mechanical seal permits use with virtually all industrial chemicals and corrosives, both liquids and gases. Temperature range is −120 to 500 F; allowable pressure is 200 psi.

lection factors considered independently. To some degree, all of the following service conditions influence the final choice:

1. Nature of the fluid being sealed, that is, pressure, temperature, corrosive or abrasive properties, viscosity and lubricity, vapor-pressure and explosiveness.

2. Speed at which the seal will operate, including consideration of both rotational and peripheral speeds.

3. Mechanical limitations of the installation, such as length or diameter restrictions in the stuffing box, allowable endplay, deflection, or whip of the shaft, and unique assembly or maintenance requirements.

4. Miscellaneous design considerations, such as the demands of a low-cost, high-production installation, permissible leakage (zero or minimum), bidirectional sealing, and possible combination of the seal with bearing races, shaft shoulders, or rotors as substitutes for the integral seal face.

In sections that follow, these factors are considered singly and in combination and are related to performance characteristics of representative mechanical seals.

Pressure-Velocity Relationship: An important criterion by which the seal designer judges the limitations of seal-face materials is the *PV* factor, that is, the product of the unit pressure acting on the seal-face junction (psi) and the rubbing velocity (fpm). Unit pressure is the total resulting from spring, bellows or diaphragm tension, plus the unbalanced portion of the hydraulic load.

For any given combination of seal-face materials, the limiting *PV* value is set by factors such as the tenacity of the film on the face surfaces, rate of heat conduction away from the heat-sensitive elements of the seal, and quality of the seal-face surfaces.

At high rubbing speeds, quality of the seal-face surfaces becomes very important. Surface quality is evaluated by roughness—expressed as an rms value—and by flatness, usually given in light bands. As speeds increase, the degree to which planes of the mating surfaces approach the true normal to the shaft axis becomes very important. For high-speed applications, say, 8000 fpm and above, the rotating plane is often specified as square with the shaft to within 0.0002 in. per inch of shaft diameter. This tolerance becomes a seal-installation problem when the stationary-type seal, Fig. 11, is employed, since trueness of the shaft shoulder or collar is normally the responsibility of the user, not of the seal manufacturer. Because looseness of the collar is reflected as seal-face wobble, compensation is sometimes provided by mounting the stationary ring in a resilient mount.

High-Temperature Applications: In comparison to the situation in oil-hydraulics systems, where temperatures do not often exceed 250 F, high-tem-

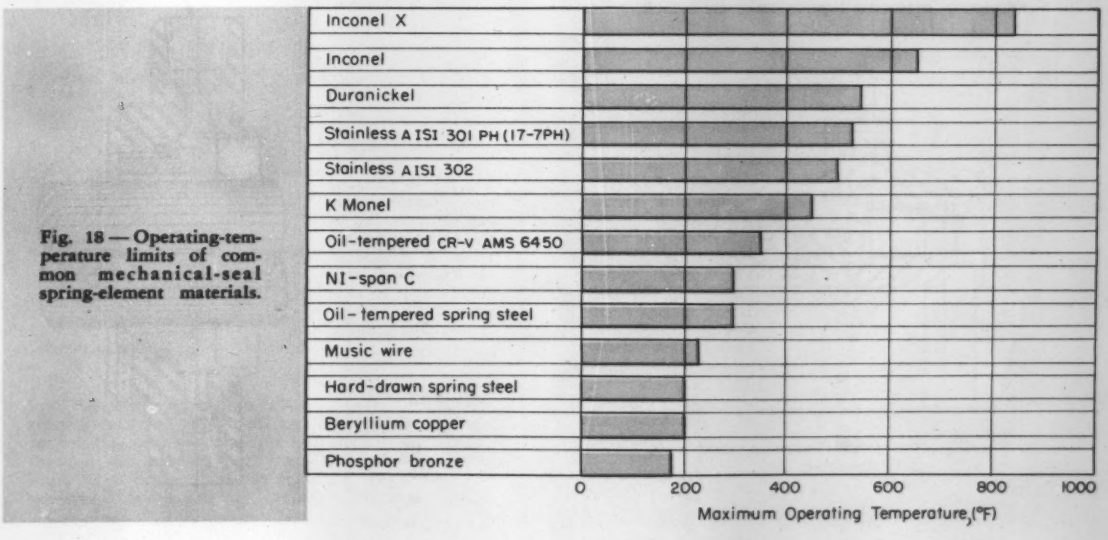


Fig. 18 — Operating-temperature limits of common mechanical-seal spring-element materials.

perature process fluids often present a more difficult sealing problem. Degree of seriousness of the problem depends upon associated circumstances. For example, some mechanical seals safely handle noncorrosive, nonvolatile fluids at temperatures as high as 500 F. More moderate temperatures, however, can give trouble if the process fluid is volatile enough to flash in the stuffing box.

Temperature of the seal rubbing surfaces is a function of both the heat derived from the fluid medium and of the heat generated by friction. Temperature limit of a mechanical seal depends not only upon the physical properties of the rubbing-surface materials, but also upon the heat resistance of organic components of the seal, Fig. 17. Most mating-face materials can withstand higher temperatures than the other seal components. Exceptions are babbitt, synthetic resins, and certain grades of carbon. Carbon in regular grades is not as a rule used at temperatures over 300 F.

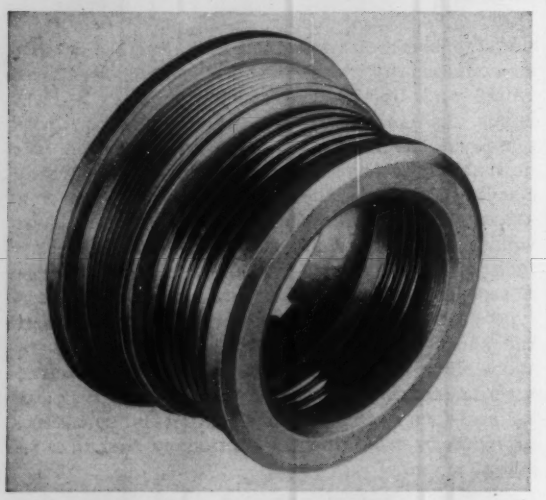


Fig. 19 — Above—All-metal bellows-type mechanical seals are available for use where extremely corrosive liquids must be sealed.

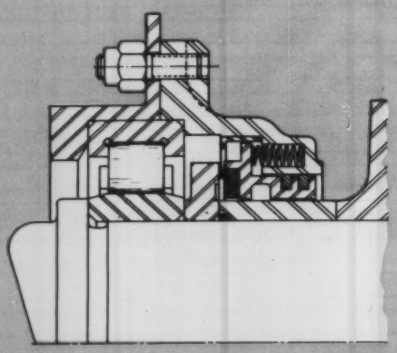


Fig. 20—Piston rings serve as static seals in this high-temperature unit.

Impregnation of carbon with metals having a high melting point and good thermal conductivity considerably extends its temperature tolerance by reducing frictional heat and improving heat dissipation.

Organic materials in the mechanical seal are generally confined to the static-seals components and must be specially selected to withstand high temperatures. Most rubber-like elastomers are limited to about 250 F. Teflon theoretically stands temperatures to 500 F, although it may have to be stress relieved to avert troubles caused by dimensional instability. Glass-filled Teflon appears to be dimensionally stable up to 450-500 F.

At extremely high temperatures, the spring-element material may give trouble. Production seals in current use employ either coil springs or the wavy-washer type fabricated of metals shown in Fig. 18. Selection of spring material is guided by the potential compatibility of the finished part with its environment. This involves both its corrosion resistance and its ability to maintain the desired spring rate over a wide temperature range.

Metal-bellows seals, Fig. 19, offer an alternative where synthetic elastomers are unsatisfactory because of the possibility of chemical attack. Because bellows are usually limited to hydraulic pressures compatible with the metal of construction, the type finds use in the low to medium pressure range, particularly in the larger bellows sizes.

A recent development for high-temperature service is a mechanical seal employing piston rings as static-seal elements, Fig. 20. Possibility of slight leakage around the rings must be considered with this type.

Aside from the problem of selecting the mechanical-seal materials best suited to the high-temperature demands of the application, the fol-

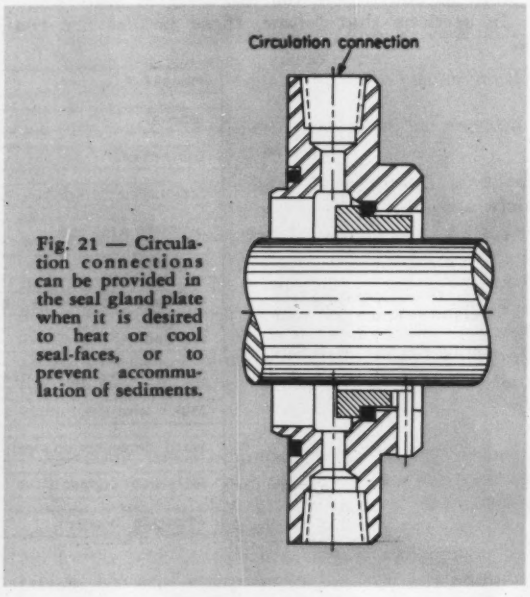


Fig. 21 — Circulation connections can be provided in the seal gland plate when it is desired to heat or cool seal-faces, or to prevent accommulation of sediments.

lowing installation factors require the user's special attention:

1. Seal faces must not be allowed to get hot to destroy the interface liquid film.
2. Process fluid must be prevented from vaporizing around the seal faces, since this destroys the sealing-face film.

To combat these possibilities, a gland-plate cooling arrangement can be provided, Fig. 21. As alternate cooling means, the process liquid or an auxiliary liquid can be circulated between double seals.

Seal-Media Compatibility: One of the most common elements used in the seal-face pair is carbon. Although compatible with most process media, carbon is affected by strong oxidizing agents, including fuming nitric acid, hydrogen chloride and high-temperature air. Oxidation of carbon begins in air at temperatures between 600 and 800 F, depending upon the formulation. Specially treated carbon can resist oxidation at temperatures to 1200 F. Normal mating-face materials for carbon are hard steel, stainless steel, or one of the cast irons. The best combination depends on factors in addition to corrosiveness of the sealed medium.

Other sealing face combinations that have proved satisfactory in corrosive service are ceramic against ceramic, ceramic against carbon, and carbon against glass. The ceramics are also mated with the various hard-facing alloys or hard electroplated surfaces.

The possibility of galvanic corrosion must also be considered in a mechanical-seal installation. Obviously, aluminum forming part of a water pump with a carbon seal face would corrode. Insulating the carbon or anodizing the aluminum helps the situation. Bronze and cast iron may be combined with carbon in such an installation with little danger of galvanic action.

Sealing Abrasive Media: Where the sealed liquid is abrasive or gritty, one seal face must effectively resist abrasion and the other must have either good embedability characteristics or sufficient pliability to allow the abrasive particles to pass through without damaging the surface. Successful combinations are tin-based babbitt or hard steel mating against hard steel (the latter combination requires lubrication), and molded plastic or rubber rubbing against hard steel. Limiting temperatures and chemical characteristics of these materials must, of course, be taken into account. Carbon-carbon mating faces are not generally used unless the rubbing area is continually flushed.

The external flushing arrangement, Fig. 22, is used where the process fluid is highly abrasive. To be effective, the injected fluid must be at a higher pressure than the sealed medium pressure. In addition, the seal housing should be provided with a throat-bushing restriction. Usually a certain amount of product dilution will occur with

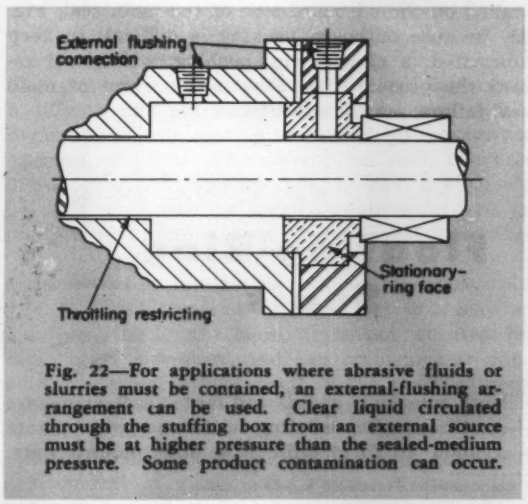


Fig. 22—For applications where abrasive fluids or slurries must be contained, an external-flushing arrangement can be used. Clear liquid circulated through the stuffing box from an external source must be at higher pressure than the sealed-medium pressure. Some product contamination can occur.

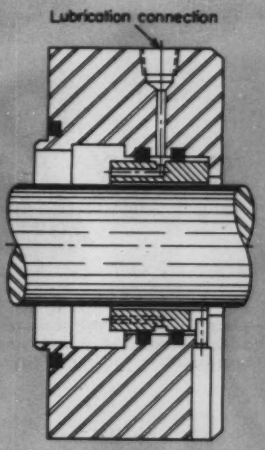


Fig. 23—Dry running of seal faces can be prevented by porting a lubricant to an annular groove in the stationary seal face.

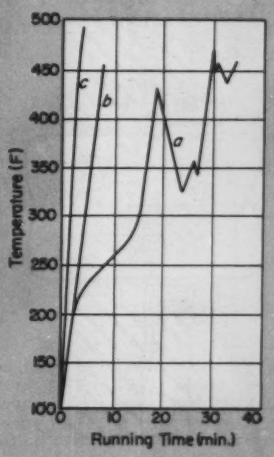


Fig. 24 — Time-temperature curves for various seal-face lubrication conditions. Curve *a* shows temperature history when seal faces were run 24 min with liquid in cavity, and then drained and run dry. Curve *b* shows temperature rise when seal faces were oiled before run was started. Curve *c* represents history for dry-running seal faces.

this arrangement, and the amount of dilution will depend upon the design of the throat restriction and the differential pressure between the stuffing box and the process fluid.

Where the process medium is extremely abrasive, the double seal has advantages. Pressure of the between-seal liquid is maintained at a value higher than that of the process fluid, preventing entry of process-fluid particles.

Sealing Viscous Fluids: Probable reason for the difficulty encountered in sealing viscous fluids is that they form comparatively thick films which offer little resistance to leakage flow. Tests show that up to about 300 SSU viscosity, standard seal construction can be used. Over this value, usual solution is to use higher spring pressures so as to prevent excessive growth in film thickness. The problem then becomes one of selecting materials capable of withstanding high surface loads, particularly materials that stand up under the poor lubrication conditions that accompany high face loadings.

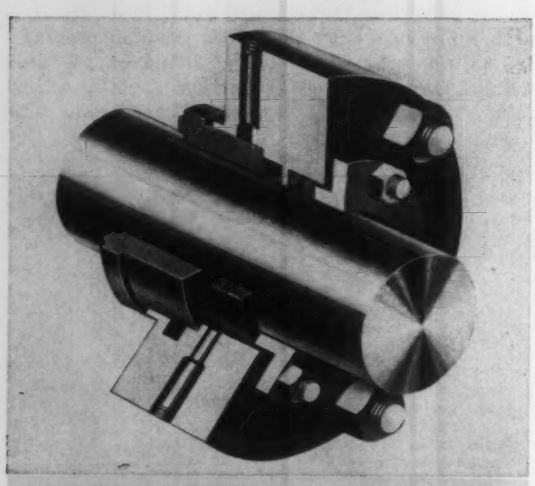


Fig. 25—Above—Auxiliary packings in the gland plate of a mechanical-seal installation provide added protection where process fluids are highly corrosive or present a fire hazard.

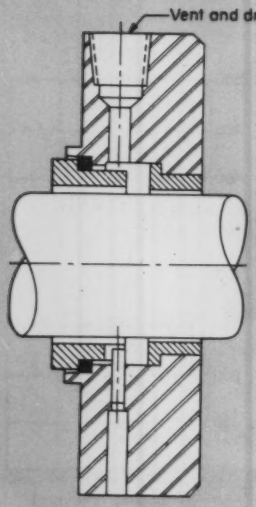


Fig. 26 — Where process fluids are not extremely toxic or explosive, an auxiliary throttling bushing provides auxiliary protection in the event of seal failure.

Sealing-Face Lubrication: Where seal faces tend to run dry or where metal runs against metal, lubrication of the seal faces may be required. Lubrication may be accomplished by porting a lubricant to an annular groove in the stationary seal member, Fig. 23.

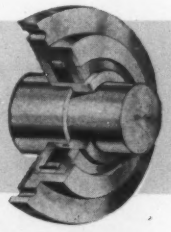
For dry-seal operation, that is where no liquid at all can be provided between the rubbing faces, seal-face materials must be specially selected to be self-lubricating and to have a low coefficient of friction. One of the faces in a dry-running seal is usually a carbon-graphite material. Load on such surfaces must be light, and a low thermal resistance path is required to carry away the heat. In such cases, the stationary seal seat should be shrunk or soldered into its housing, rather than being surrounded by a resilient ring which is a poor conductor of heat.

Carbon running against glass, Steelite, or hard steel has also been used in dry seals. Drawbacks of these combinations are in their high coefficients of friction and the poor thermal conductivity of carbon. Wherever possible, dry-running seal-face surfaces should be avoided by providing a good supply of liquid in the seal chamber. Typical time-temperature curves for various seal-face lubrication conditions are plotted in Fig. 24.[1]

Sealing Volatile Fluids: To prevent vapor lock at the seal faces when the process fluid is highly volatile, product recirculation in the seal cavity is widely used. Recirculation also has a cooling effect on seal faces, since the liquid is not dead-ended in the stuffing box. Fallout of abrasive particles in the stuffing box is also minimized. Recirculation is not recommended when the media is hot.

Where the process fluid presents a fire hazard, auxiliary stuffing boxes or glands are often installed on the outboard side of the main seal, Fig. 25. Because outboard packing is difficult to keep lubricated, a close-fitting bushing, which will retard the process fluid flow in the event of main seal failure, may be substituted, Fig. 26.

Floating-Ring Seals



High rotational speeds and large shaft diameters —conditions often existing in turbine power plants —combine to form difficult sealing requirements.

[1]References are tabulated at end of article.

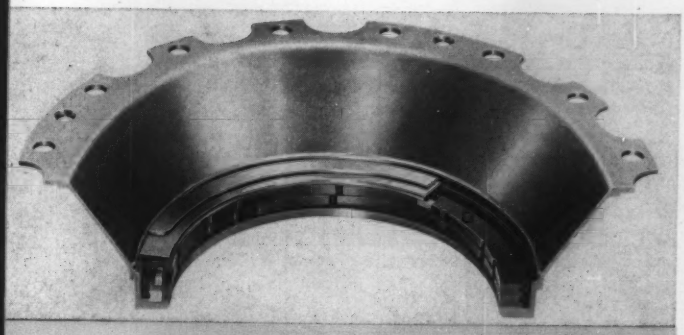


Fig. 27—Above—Segmented carbon-ring seal. Garter springs hold segments in contact with the shaft; multiple compression springs maintain positive pressure against the side of the groove. Effective in sealing gases in gas-turbine engines, this design is difficult to balance hydraulically, may require oil-jet cooling of the interface at high gas pressures.

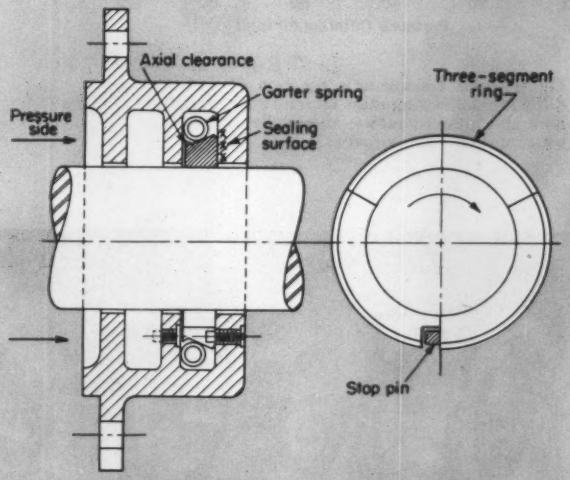


Fig. 28—Butt joints are cut on radial lines in this segmented-ring seal. Leakage between the ring and the shaft is held to a low value by a minimum-clearance fit. Average cold clearance for a 2-in. diam shaft, assuming 600-F shaft working temperature, is 0.006 in.

The gas-turbine engine, in particular, represents a difficult problem since temperatures vary widely during operation, leading to axial-shaft movements as high as 0.5 in. The carbon-ring seal, one version of the floating-ring type, is used extensively as a pressure seal in turbine engines, as well as in industrial compressors, blowers, and fans, Fig. 27.

Compared to the labyrinth seal, the carbon-ring seal attains higher sealing efficiency in a shorter axial length. Furthermore, it is not affected by axial shaft movement and can accommodate considerable radial displacement of the shaft without danger of seizure or loss of sealing efficiency.

Segmented-Ring Seals: Representing continued development of a seal used widely in steam turbines, the segmented-ring seal, Fig. 28, is fabricated in diameters exceeding 40 in. Ends of individual carbon segments are cut on radial lines so that they form a complete circle with no clearance between butt ends.

In application, the inside diameter of the segmented ring is given a minimum-clearance fit with the shaft. Pressure drop due to throttling of fluid in the clearance holds leakage to a small value. Because ends of the segments abut in this type seal, fluid pressure cannot cause the ring to bear against the shaft with any great pressure. Sliding contact between the face of the segmented ring and the housing allows free movement of the ring in any radial direction. In the type shown in Fig. 29, compression springs are used to take up axial play prior to buildup of hydraulic-pressure.

Where high pressures must be sealed, the number of carbon rings is usually specified so that pressure drop across each ring is from 20 to 30 psi. The complete packing assembly is made up of a number of rings, each in a separate compartment. In this way, pressures of several hundred psi can be effectively sealed. If initial cold clearances are correctly specified, surface velocities up to 10,000 fpm can be accommodated.

Continuous-Ring Seals: Component parts of a

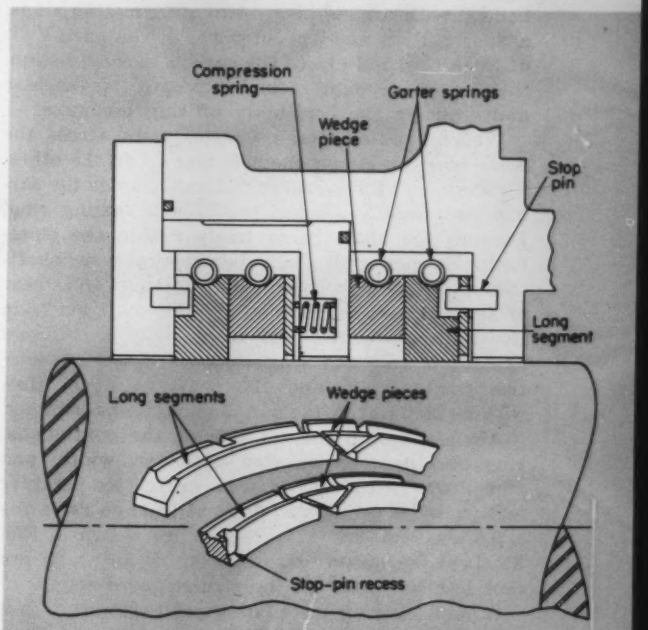


Fig. 29 — Overlapping segment carbon-ring seal. Multiple coil springs insure initial contact at side faces of rings. Segment joints are open 0.010-0.020 in. when segments are new. As ring wears in, gaps close up and wear is reduced to negligible value.

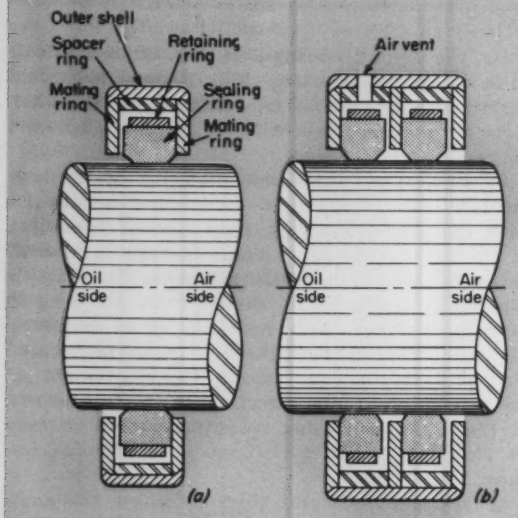


Fig. 30—Tensile strength of the continuous carbon ring in the single-element seal, *a*, is supplemented by a retaining band. In the tandem-ring seal, *b*, the greater part of the air-oil differential pressure is taken by the right-hand ring. Leakage is vented to an external low-pressure area.

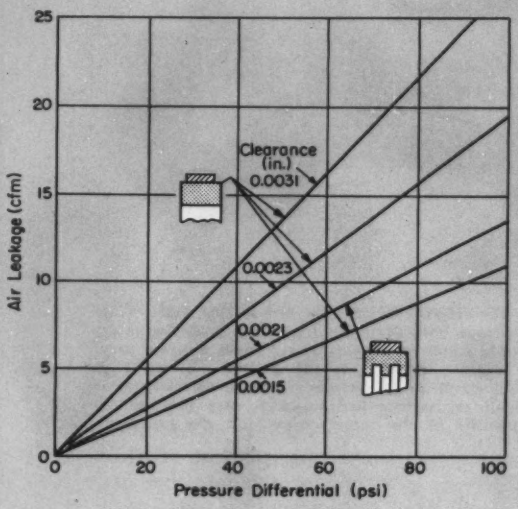


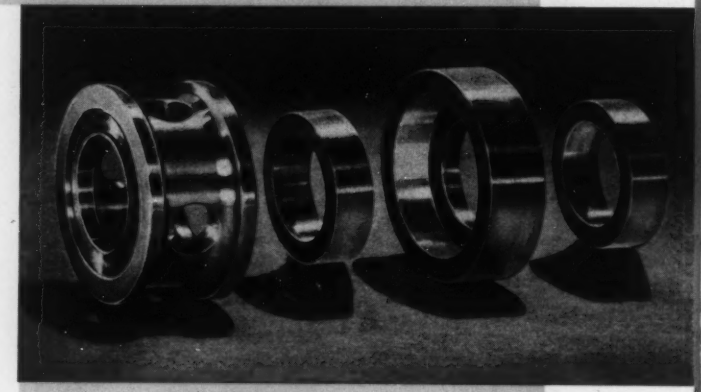
Fig. 31—Air leakage as a function of pressure differential and ring-shaft clearance for straight-bore and grooved carbon rings. Results shown were obtained for air at 80 F.

typical continuous-ring seal, shown in Fig. 30, are an annular seal ring—in this case of carbon banded with a steel hoop—two steel mating rings, a spacer ring, and an outer shell. The shrink fit of the steel band places the carbon in compression, thereby overcoming tensile-strength weaknesses and reducing the possibility of ring breakage.

Where a differential pressure exists across the seal—between air on one side and oil on the other, for example—the pressure difference holds the carbon ring axially against the oil-side mating ring. Because the shaft turns freely within the close-fitting carbon ring, there is practically no shaft-to-seal rubbing contact, and heating and wear of seal components is small. If the shaft shifts in the radial direction due to loading or thermal expansion, the seal ring assumes a new concentric position, allowing the shaft to again turn within the seal with minimum rubbing contact.

Air leakage to the oil side of the continuous-ring seal depends on ring diameter, width, and ring-shaft clearance, as well as on temperature and pressure of the air. Typical leakage rates for a 5.5-in. diam, 0.4 in. wide seal are shown in Fig. 31. Leakage of the grooved ring is about 20 per cent less than that of the straight-bore ring.[2]

A multiple-ring installation of the floating seal is shown in Fig. 32. In this type, rings are carbon, plastic, steel, ceramics, or overlays. Where necessary to establish initial sealing pressure, an axial spring is provided. At high pressure differentials, a narrow sealing ledge at the opening of the seal chamber reduces axial hydraulic forces to a minimum.



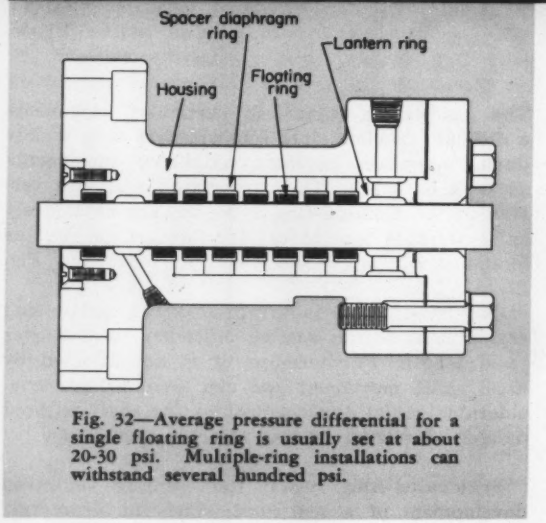


Fig. 32—Average pressure differential for a single floating ring is usually set at about 20-30 psi. Multiple-ring installations can withstand several hundred psi.

DYNAMIC PACKINGS

Types of motion, pressure, and temperature are deciding factors in the selection of a packing device. Although frequently used for sealing rotating shafts, the packed stuffing box is perhaps best suited to high-pressure applications involving reciprocating motion, or combinations of reciprocating and rotating motion. Familiar examples are the rods and plungers on reciprocating pumps, compressors, and steam engines.

In selecting a packing, it is necessary to relate characteristics of each type to the service conditions for which it is best adapted. Classification of packings generally breaks down into the following categories:

1. Simple compression.
2. Molded synthetic rubber.
3. Leather.

Compression Packings

Oldest of the packing forms, the simple compression packing is composed of fibers which are first woven, twisted, or braided into strands, and then formed into coils, spirals, or rings. To insure initial lubrication and to facilitate installation, the basic material is often lubricant impregnated. Common materials are asbestos fabric, braided and twisted asbestos, rubber and duck, flax, jute, and metallic braids. The so-called "plastic" packings can be made up with varying amounts of asbestos fiber combined with a binder and lubricant for high-speed applications, either rotating or reciprocating. Maximum temperatures that base materials of packings withstand and still give good service are indicated in Fig. 33. Other characteristics of the various compression-packing forms are given in following sections.

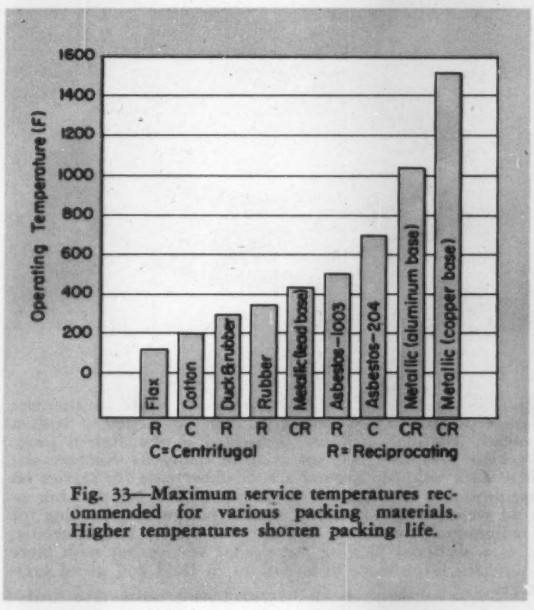
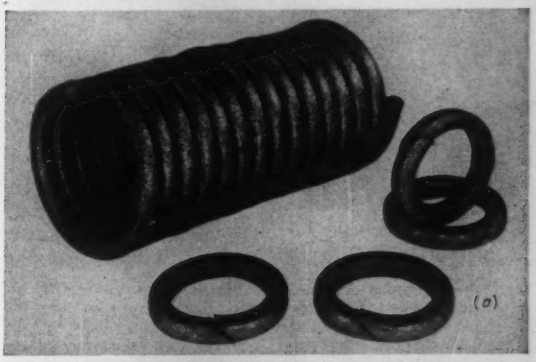
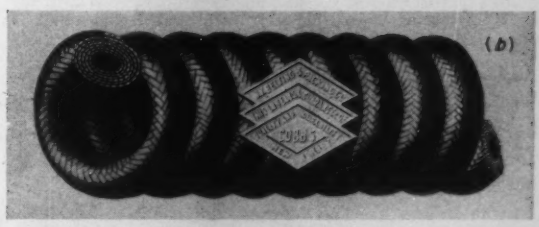


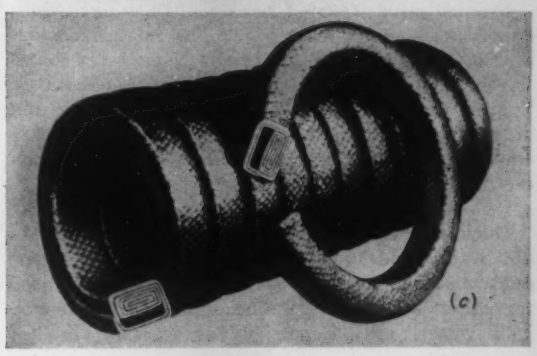
Fig. 33—Maximum service temperatures recommended for various packing materials. Higher temperatures shorten packing life.

Asbestos-Fabric Packings: Because of the minimum number of fibers exposed to wear, the asbestos-fabric packing, Fig. 34, provides a durable surface for high-temperature service. When saturated with a sealing compound, the asbestos-fabric construction forms a solid, resilient mass that blocks penetration of liquids and gives long life and efficient performance. The asbestos-fabric

Fig. 34—Typical asbestos-fabric packings. These compression packings have an outer cover of asbestos cloth wrapped around an inner core of resilient material, which can be rubber and duck or asbestos. Packing *a* is commonly used for sealing piston rods in steam engines, air compressors, steam pumps, and similar applications where temperatures stay under 600 F; *b* is good for steam pressures up to 150 psi, hot or cold water, hot tar; *c* is designed for reciprocating rods and plungers working against high-pressure steam, air, and gas up to 500 F.







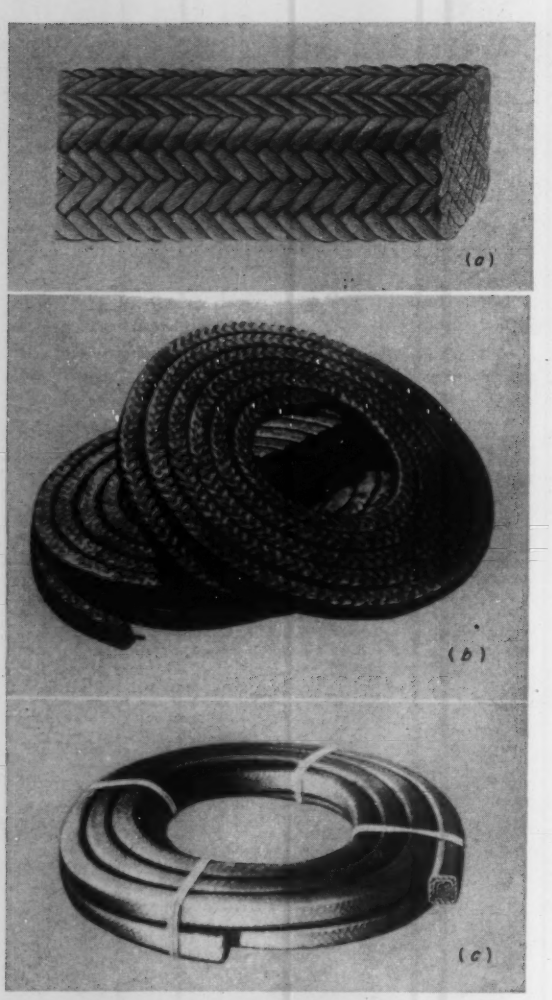


Fig. 35—Examples of braided asbestos packings, which can be of interlocked braided, square-plaited, braid-over-braid, or twisted construction. Enlarged view, *a*, shows section of braided asbestos packing; *b* is a wire-inserted, square-plaited, centrifugal-pump packing developed especially for heavy-duty service with hot tar, pitch, and asphaltum; *c* is braid-over-braid packing for reciprocating and rotating rods operating in steam, air, ammonia, oil, hot or cold water, chemicals, and some acids.

packing is an economical choice for severe-service conditions, such as those experienced with superheated steam.

Braided and Twisted-Asbestos Packing: Generally intended for less severe duty than asbestos-fabric types, braided and twisted packing forms are employed in a broader range of applications. Typical uses are in chemical-pumping service and in equipment designed to handle hot oils. Examples of techniques employed in the fabrication of this packing type are shown in Fig. 35.

Duck and Rubber Packings: Highly durable in hot water and low-pressure steam service, some duck and rubber packings, Fig. 36, may be used for other services, including light oils, ammonia, cold water, etc. Tendency for swelling in hot

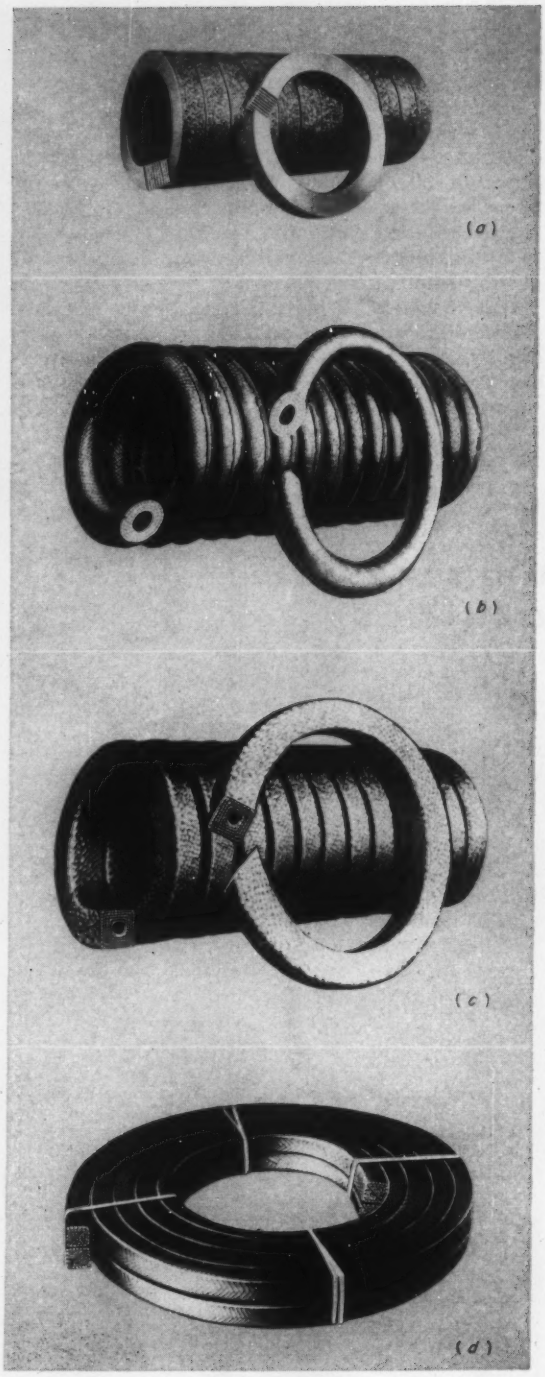


Fig. 36—Duck and rubber packings are made of alternate layers or plies of woven duck cemented together with a rubber "friction" and cut or molded to the desired form. Packing *a* is designed for rods of ammonia compressors; *b* is duck wrapped around a red rubber core for service on reciprocating rods against steam up to 150 psi, and hot or cold water; *c* is a resilient, square, hollow-core packing for medium-pressure steam, hot or cold water, and ammonia; *d* is a sectional packing for similar service but with more automatic adjustment to variations in fluid and gland pressures.

water is compensated by the natural resiliency of this type of construction, which consists of duck laminated with rubber specially compounded for the recommended conditions.

Flax and Jute Packings: Recommended for cold-water reciprocating service, most flax and jute packings look alike, Fig. 37. Durability is largely governed by quality and length of fiber, as well as by type of impregnation used. The two most important grades of fiber used in the manufacture of flax packing are "line" flax, which is the longest, highest-grade fiber, and "tow" flax, which is of shorter length.

Flexible Metallic Packings: Suitable for reciprocating and rotating rods and shafts with relatively fine finishes and fitted to close tolerances, flexible metallic packings are made to withstand severe service under high pressures and temperatures. Caution should be observed, however, in specifying metallic packings for operation against certain shaft metals. For example, they should not be used on brass or bronze rods or shafts, or in any service where base metals of shaft and packing are of similar material.

These packings are made in many different styles, Fig. 38, including all-metallic and semi-metallic, in both solid-braided and channel types. The channel types generally are combined with other flexible metallic packings, thereby providing resilience with an effective barrier against penetration.

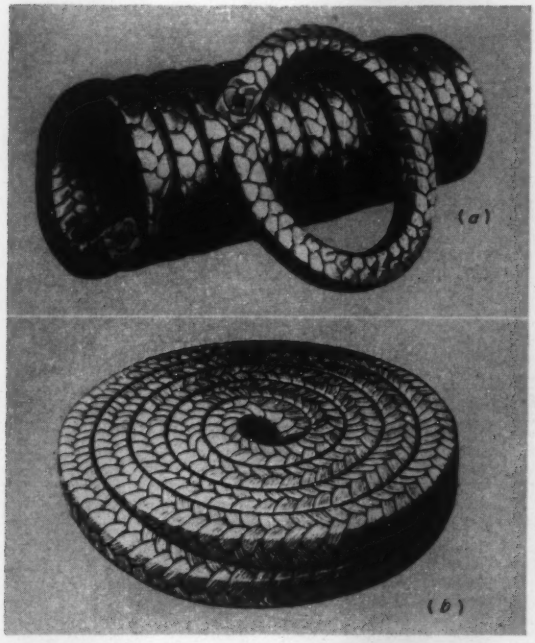


Fig. 37—Typical flax and jute compression packings recommended primarily for cold-water reciprocating service. Some of these packings may also be used against cold oil or brine. Packing *a* is made of waterproof flax with a red rubber core; *b* is a braided jute packing that can be supplied with more than standard quantity of lubricant.

Plastic Packings: So-called "plastic" packings are tough, ductile materials that seal effectively with low friction. They are particularly successful in high-speed rotary service.

Considerable variation exists in plastic-packing styles, Fig. 39. A major consideration in selection is to obtain the most satisfactory combination of asbestos fiber, lubricant, and other materials in the right density for the particular conditions of operation.

Combination Packings: To meet special requirements of many types of equipment, combination packing sets, such as fabric or braided types combined with metallic or plastic types, are often assembled. One style employs metallic "junk rings" or "bull rings" as end rings in combination with other packing types. The end rings bear the brunt of first contact with high temperature or high

Fig. 38—Examples of flexible metallic packings made to withstand relatively severe temperature and pressure conditions on reciprocating and rotating rods and shafts. Aluminum, copper, and lead foils are common materials for these packings. Center cores may be of asbestos, flax, or a plastic compound, depending on service requirements. Variety *a* is an all-metallic packing recommended for close fits and fine finishes and is made from layers of low-friction foil spirally wrapped around a small core; *b* is a packing of thin metal foil spirally wrapped around a fibrous or non-metallic center core, thus combining durability of metallic surface with resiliency of a fibrous packing.

pressure fluids. They will withstand such conditions and protect the softer, more sensitive packings against extrusion through gland or housing clearances.

Compression - Packing Application: Coils and spirals are cut to form closed, or nearly closed rings in the stuffing box. Clearance between ends should be sufficient to allow for fitting and possible expansion due to swelling of the packing while in operation.

Correct form of the ring joint depends on materials and service requirements. Braided and flexible metallic packings usually have butt or square joints, Fig. 40*a*. With other packing materials, service experience indicates that rings cut with bevel or skive joints, Fig. 40*b*, are more satisfactory, particularly on reciprocating pump rods. A slight advantage of the bevel joint over the butt joint is that the bevel permits a certain amount of sliding action, thus absorbing a portion of the ring expansion.

LUBRICATION: In the manufacture of packings, the proper grade and type of lubricant is usually impregnated for each service for which the packing is recommended. However, it is impossible to provide sufficient lubrication to last the normal operating life of the packing. Lack of lubrication causes packing to become hard and lose its resiliency, thus increasing friction, shortening packing life, and increasing operating costs.

An effective means of renewing packing lubrication on rods, and particularly on rotating shafts, is to provide a lubricating lantern ring. The ring

Fig. 39—A typical asbestos "plastic" packing containing fibrous asbestos, metal, and other ingredients thoroughly coated with prepared lubricants to insure a resilient mass. Unaffected by sustained heat or pressure, this packing molds itself to a stuffing box of any size or shape and is recommended for general service conditions against steam, air, water, oils, ammonia, gases, and distillates. To confine the packing, conventional rubber and asbestos end rings should be used.

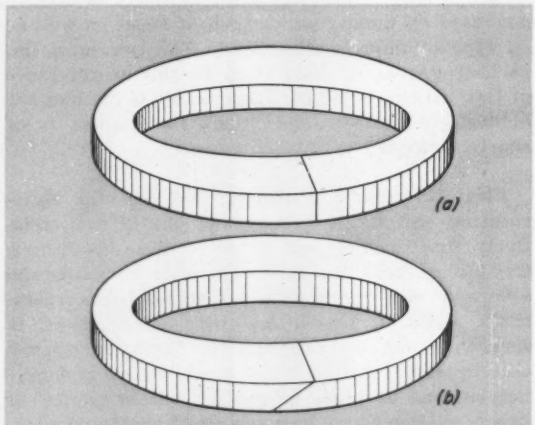


Fig. 40—Butt or square joint, *a*, and bevel or skive joint, *b* in compression packing rings.

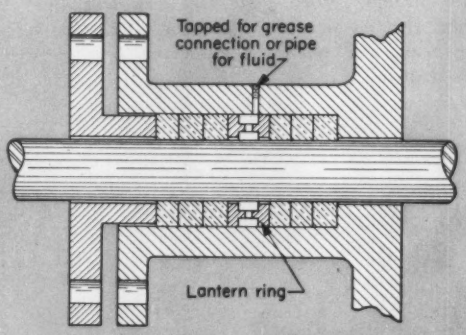


Fig. 41—Typical arrangement of lubricating lantern ring in stuffing box. Although packings are often impregnated with lubricant, proper lubrication must be maintained during operation.

Table 2—Typical Synthetic-Rubber Physical Properties

Characteristics	Natural Rubber	Chloroprene (Neoprene)	Buna N (Hycar) (Chemigum)	Polysulfide (Thiokol)	Buna S (GR-S)	Isobutene Isoprene Butyl	Silicone (Silastic)	Kel-F	Poly FBA	Vyram
Tear resistance	Good	Fair	Fair	Fair	Poor	Good	Fair	Good	Good	Fair
Abrasion resistance	Excellent	Excellent	Good	Poor	Good	Fair	Fair	Good	Poor	Fair
Aging caused by										
Sunlight	Poor	Excellent	Fair	Good	Poor	Excellent	Excellent	.....	.....	.....
Oxidation	Good	Good	Fair	Good	Good	Good	Excellent	Good	Good	Good
Resistance to flexing	Good	Good	Good	Poor	Good	Very good	Fair	Good	Poor	Fair
Resistance to compression set	Good	Fair	Good	Poor	Fair	Fair	Good	Poor	Poor	Fair
Oil and gasoline resistance	Poor	Good	Excellent	Excellent	Poor	Poor	Fair	Good	Good	Fair
Acid resistance	Excellent	Excellent	Good	Fair	Good	Excellent	Poor	Excellent	Fair	Fair
Cold resistance ("freezing")	Good	Good	Good	Poor	Fair	Good	Excellent	Good	Poor	Poor
Heat resistance	Fair	Fair	Good	Poor	Fair	Fair	Excellent	Good	Good	Fair
Permeability to gases	Medium	Low	Medium	Very low	Medium	Very low	Medium	Good	Fair	Fair
Electrical resistivity	High	Medium	Low	High	High	High	High	High	High	High
Resistance to cutting	Excellent	Good	Good	Poor	Fair	Fair	Poor	Good	Fair	Fair
Resistance to water swelling	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Good	Good	Good	Fair

forces oil, grease, or the sealed medium into the packing set, giving a constant supply of lubricant, Fig. 41. This method of lubrication is particularly effective on pumps handling volatile liquids.

Lantern rings are also employed for cooling, to provide an additional seal against leakage of liquids being pumped, and to prevent infiltration of air through the stuffing box on the pump suction side.

In centrifugal-type water pumps where no lantern ring is used, a small amount of leakage through the packing is recommended, since water is a good lubricant.

Molded Synthetic Packings

Polymers used in making molded synthetic packings are characterized by varying temperature tolerance and resistance to specific fluids. Elastic memory, however, is the most valuable attribute of the 12 or so commercially useful polymers. Approximately 20 compounding ingredients are available to reinforce these polymers or to change properties such as hardness, modulus of elasticity, tensile strength, low-temperature flexibility, heat resistance, etc. Thus, the number of possible combinations is very large.

Practically all fluids, except molten metals, can be tolerated to some usable degree by existing rubber compounds, including Neoprene, Buna N, Butyl, GR-S, Hycar PA, Hypalon, Adiprene, silicones, Poly FBA, Viton A, Teflon, and Kel-F.

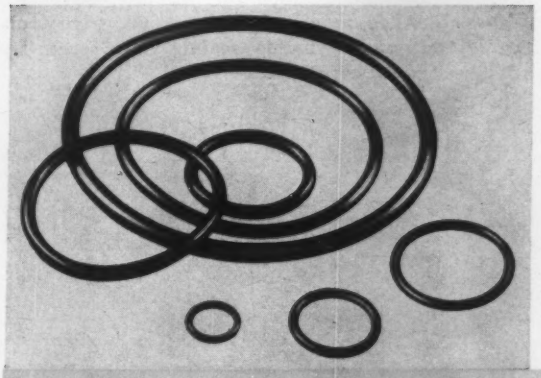
Selecting the Compound: Selection of the best compound for an application must be a compromise to obtain the desired balance of cost and physical properties, Table 2. For example, silicone rubber is usually recommended for static O-ring seals because of its relatively low abrasion resistance and tensile strength. For any environment which subjects a seal to high oxidizing temperature and limited motion, silicone rubber may well provide the best answer. Similarly, Poly FBA and Viton A may appear to be logical choices for molded packings because of their resistance to heat and many fluids. However, they are costly and require special designs, thus limiting their range of general usage.

Severity of environmental conditions is often overstressed in an effort to establish an additional safety factor. Although not harmful in many cases, this practice often imposes a severe cost penalty. For instance, Poly FBA compounds have been specified for aircraft-engine sealing applications which nominally call for −65 F operation. However, subsequent investigation showed that at −65 F no sealing was demanded. The only functional requirement at this temperature was that the seals suffer no permanent damage.

Another hazard in selecting a molded seal compound is that exaggeration of physical properties in one direction may cause loss of other, equally important properties. Conversely, an attempt to standardize on one compound for a wide range of conditions may impose penalties where service conditions are less severe.

Use of harder compounds to compensate for higher pressure may result in shorter packing life. For example, increase in hardness of a compound from 70 to 90 Durometer is accompanied by loss of elasticity and stress life and increase of compression set. These factors hasten the onset of fatigue failure and increase friction in dynamic-sealing applications. Therefore, it is often preferable to

Fig. 42—Typical synthetic-rubber O-rings. Size of cross-section is not necessarily related to diameter of ring. However, usage has led to adoption of certain standard sizes ranging from about 1/32-in. ID, 3/32-in. OD, and 1/32-in. cross-section width to about 15½ in. ID, 16 in. OD, and ¼-in. width, in enough increments and variations to satisfy most requirements.



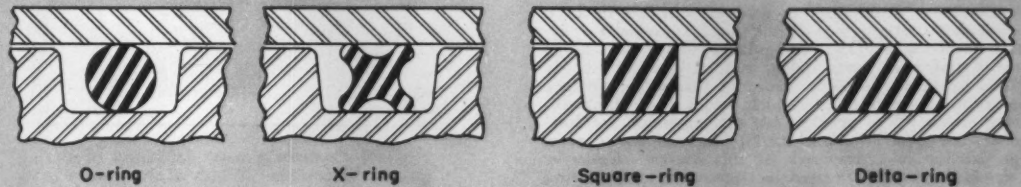


Fig. 43—Cross-sections comparing O-ring with sealing rings of less common configurations.

obtain high-pressure extrusion resistance by using closer fits or suitable back-up rings.

Selecting Molded Packing: There are four major forms of molded synthetic packings for sealing rotating and reciprocating shafts. These forms are commonly known as:

1. O-rings
2. V-rings
3. U-cups
4. Flange packings

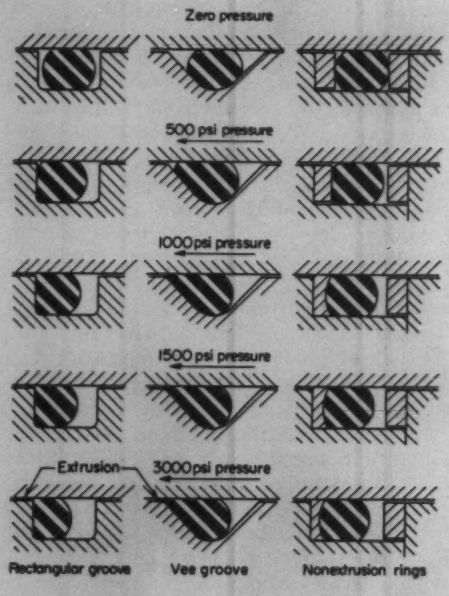


Fig. 44—Effect of various pressures on O-rings in rectangular and vee grooves. Behavior with back-up or non-extrusion rings is also shown.

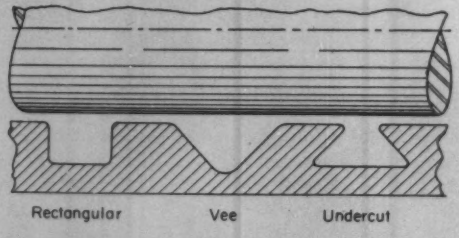


Fig. 45—Three gland-recess or groove shapes for O-rings. *Rectangular* configuration is the most common for dynamic applications. In rectangular grooves, sides slope outward not more than 5 deg, and outside corners are broken to about 0.005-in. radius. Inside corners are rounded to a small radius which varies somewhat with O-ring width. *Vee* grooves are recommended for low-temperature applications, where they increase the squeeze. High friction is a drawback of this design. *Undercut* or dovetail grooves are used in slow-speed reciprocating applications, where they reduce tendency for extrusion and reduce friction. A deterrent to their use is high cost of manufacture.

O-RINGS: An O-ring is a circular ring, or torus, of synthetic rubber with a round cross-section, molded and trimmed to close tolerances, Fig. 42. Operation principle of the O-ring is simple, depending on only two fundamental requirements: 1. Installation should be between two surfaces spaced apart at less distance than the width, or cross-sectional diameter, of the ring. 2. Elastic memory of the ring material should be sufficient to maintain the original width and hence exert a force against the spaced surfaces.

Thus, an O-ring installed in a groove effects a seal through both compression and fluid pressure. Primary seal is made at installation when the O-ring is squeezed between facing surfaces. When pressure is applied, it increases the force acting on the surfaces and enhances the degree of sealing. These conditions hold true for other configurations, such as rectangular, lobed, triangular, Fig. 43.

In reciprocating applications, relative motion is normal to the plane of the ring, thus carrying a film of fluid across the working face of the ring and extending contact area. Some lubrication is therefore insured, and the working face is maintained at acceptable temperature.

Neither of these effects is present in a rotary application. Elastic and fluid pressures tend to squeeze out the lubricating fluid at the contact face, and continuous operation against the same small area of metal induces excessive localized heating. If severe enough, this action damages the rubber compound and possibly the shaft, and sealing is impaired. Hence, rotary sealing with O-rings is limited by both pressure and surface speed. No definite limits are set, but generally 300 fpm is considered maximum rubbing speed at very low pressure. As speed is decreased, pressure can be increased, the practical limit being a static seal installation at about 1500 psi pressure.

O-Ring Advantages: Increasing popularity of the O-ring as a dynamic sealing device can be attributed to these factors:

1. Low initial cost.

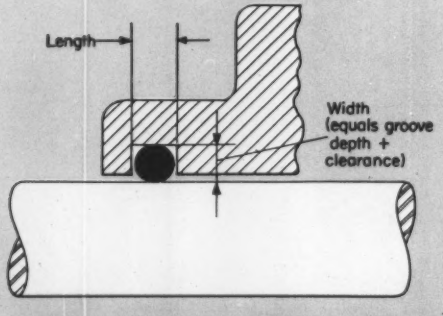


Fig. 46—Commonly used definition of O-ring groove dimensions. Width of the groove is its depth plus clearance between shaft and housing. Length of groove is distance between walls.

2. Adaptability to limited space.
3. Ease of installation.
4. High efficiency.
5. No need for adjustment.
6. Tolerance to wide ranges of pressure, temperature, and fluids.
7. Sealing in two directions.
8. Relatively low friction.

Limitations: To obtain the advantages of O-ring seals, somewhat closer tolerances and finer surface finishes must be specified than with some other types of packings and seals. With more relaxed standards, particularly with larger equipment, life expectancy of the O-ring is inferior to that of some seal types. Life is also generally decreased about 60 per cent for each doubling of pressure in the range above 1000 psi.

At pressures over 1500 psi, some form of extrusion protection, such as leather or Teflon backup rings, must be used, together with a very small radial clearance, Fig. 44. Over 3000 psi, extrusion is prevented only with extreme precaution.

O-Ring Application: Operating conditions determine dimensions, material, finish, and other factors in the design of O-ring glands and grooves. Clearance between moving parts should be held to a workable minimum. Polished chrome or nickel-plated rods and honed-steel or cast-iron bores are recommended. All sharp edges should be eliminated to prevent cutting of O-rings during assembly.

Finish of working surfaces should be as smooth as possible. A microinch finish of 4 to 16 rms is recommended for dynamic applications. Finish should be ground concentrically for rotary sealing and longitudinally for reciprocating sealing.

Groove finish is generally a compromise between O-ring life and best possible performance. Too smooth a finish causes leakage but extends O-ring life. Rougher finish wears an O-ring faster but makes a better seal. Too rough a finish shortens life and impairs performance. An overall "best" groove finish cannot be recommended, since many variable factors, for example, motion, speed, pressure, and cost, contribute to the establishment of the correct finish for a particular application.

Three shapes for the groove or gland recess are generally recommended, Fig. 45: 1. Rectangular. 2. Vee. 3. Undercut.

Size of the O-ring groove, which is a product of groove width and length, Fig. 46, should provide a groove volume approximately 15 per cent greater than the O-ring volume. This allows the O-ring to roll, facilitates assembly, and permits swelling of the O-ring under fluid action.

Width of the groove equals its depth plus the radial clearance between the shaft and housing. It should be at least 10 per cent less than the O-ring width to create the squeeze that effects initial sealing.

Length of the groove, that is, the distance be-

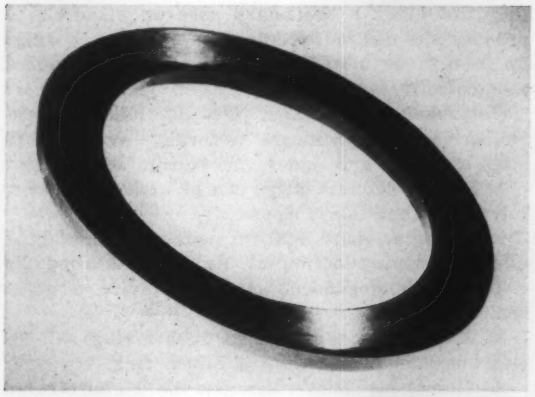


Fig. 47—Molded synthetic-rubber V-ring.

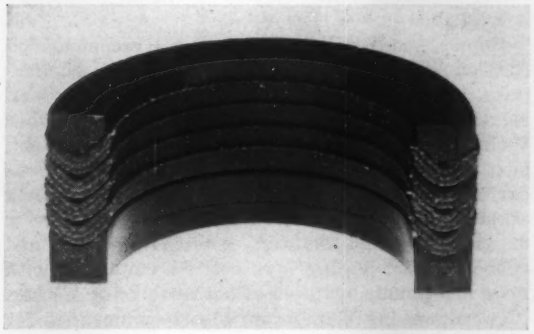


Fig. 48—Cutaway view of set of four fabric V-rings with male adapter at top and female adapter at bottom.

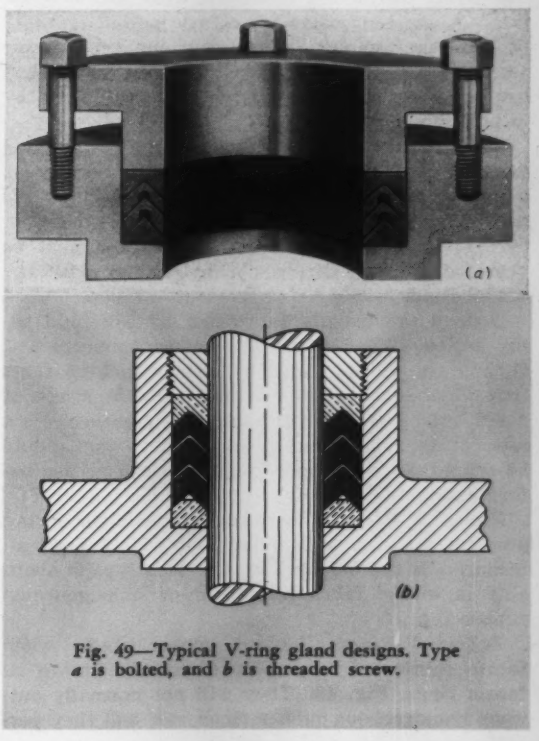


Fig. 49—Typical V-ring gland designs. Type *a* is bolted, and *b* is threaded screw.

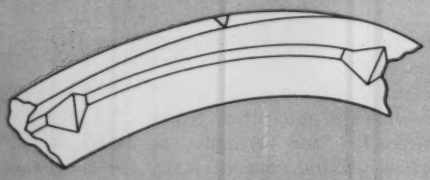


Fig. 50—Method of preventing annular labyrinth leakage in sets of cut V-rings. This is a fabric Vee-Dam ring, characterized by soft rubber dams at intervals in the root of the internal V. Offering an exception to the principle of snug, but not forced fit, as specified for plain V-rings, gland pressure on Vee-Dam rings should be sufficient to overcome dam interference. This construction is not practicable in homogeneous rings, as the dams must be of softer material than the ring stock.

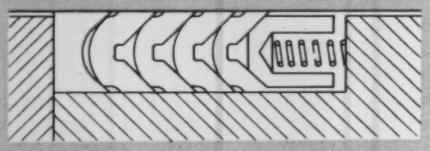


Fig. 51—Spring biasing for V-rings. This arrangement prevents over-tightening, ensures automatic wear take-up, and allows a fixed stuffing-box length.

tween walls, is generally about 1.5 times O-ring width, but varies with operating conditions. A longer groove for reciprocating motion enables the O-ring to roll and distribute wear over a wider area. A shorter groove for rotary motion prevents or reduces "snaking," thus reducing undesirable stresses. Grooves should not be too long when back-up rings are used, or the rings will not stay in position.

Multiple O-ring applications are not recommended, since they tend to jam the assembly as a result of pressure traps between O-rings. If such an installation is necessary, space between O-rings must be vented, and lubrication must be provided for the O-ring not in contact with the sealed fluid.

O-rings are usually lubricated by the fluid being sealed. When operated in a dry environment, O-rings can be lubricated by leather back-up rings that have been saturated in a suitable grade of clean oil. With or without the presence of a lubricating fluid, both groove and O-ring should be coated with a proper grade of clean grease before assembly.

RUBBER V-RINGS: Where limitations of the O-ring preclude its use, a familiar and widely used alternative is the V-ring, Fig. 47. This type is available in either fabric-reinforced or homogeneous-rubber types.

Fabric V-Rings: Molded rubber rings, when fabric reinforced, are more commonly known as fabric rings, Fig. 48. They will not normally outwear homogeneous rubber rings, nor will they permit the use of rougher surface finishes. Major reason for the use of fabric is to provide greater extrusion resistance than homogeneous rings where high pressures and large clearances must be dealt with. Another benefit is increased stiffness, which simplifies installation, particularly of large sizes, and offers greater resistance to twisting or turning from frictional forces during operation. Fabric reinforcement also permits the molding of large-diameter rings in continuous strip molds, after which they are given a secondary cure on mandrels to produce the desired circular shape. Thus, V-rings up to 6 ft or more in diameter can be produced economically.

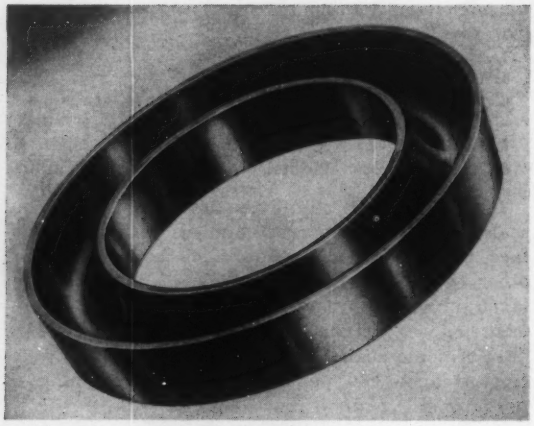


Fig. 52—Molded synthetic rubber U-cup.

Homogeneous V-Rings: Use of homogeneous-rubber V-ring packings, generally available in sizes of 15 in. and under, has certain advantages:

1. Homogeneous V-rings can be molded to closer tolerances than fabric rings.

2. Smoother, more uniform surface finish and the effective wiping action of its sharp sealing lip allow the homogeneous ring to provide a dryer seal.

3. A properly compounded rubber ring will resist abrasion better than a fabric ring.

4. Homogeneous V-rings can be manufactured in a much wider selection of compounds than fabric rings because of simpler construction requirements. Also, a wider variety of molding methods is available.

Homogeneous rubber V-rings are recommended for low and medium-pressure hydraulic applications, say, up to 1500 psi, for reciprocating and rotating shafts. At higher pressures, a leather V-ring placed at the downstream end of the set, next to the female adapter, will prevent serious extrusion up to about 5000 psi. Another method of preventing extrusion in this pressure range is to use a leather adapter. Alternate leather and rubber nested V-ring sets can be employed with male and female adapters of hard rubber or leather.

Homogeneous V-rings are also recommended for pneumatic applications where eccentricities, clearances, or finishes would cause excessive wear or failure of other types of packings. Good lubrica-

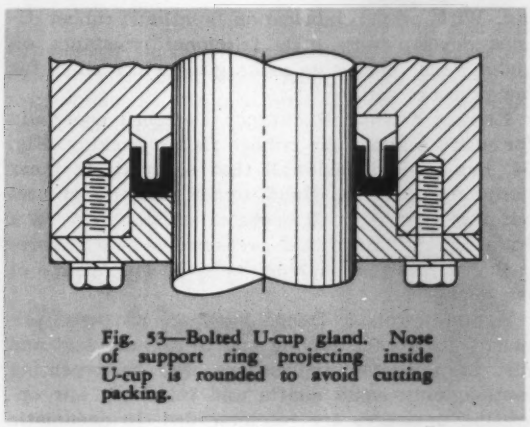


Fig. 53—Bolted U-cup gland. Nose of support ring projecting inside U-cup is rounded to avoid cutting packing.

tion must be provided because of the relatively high friction in a nested set of V-rings. Alternate leather and rubber sets can be used effectively in pneumatic applications.

V-Ring Application: Like O-rings, V-rings are automatic in operation and should not have axial gland pressure applied, since this merely increases friction and wear. However, adjustable glands must be used to produce a snug, but not compressed fit, Fig. 49.

Number of rings required in a gland varies for different conditions. More rings mean more friction. On the other hand, more rings, or increased "height of the stack," provides greater protection against pressure surges. The number of rings recommended usually represents a compromise between friction and wear factors, and is not determined by pressure alone.

Actually, if all recommendations relating to surface finish, clearances, concentricity, etc., could be strictly followed, a single uncut V-ring would do an excellent job of shaft sealing. Since these ideal conditions are not always met in mass-produced equipment, and because a safety factor of sealing effectiveness is desirable, more than one ring is usually considered necessary. Special problems are presented by cut V-rings, Fig. 50.

Adequate radial clearance must be allowed for installation of V-rings over or through threaded surfaces or other sharp projections. Approximately 10 per cent of the free cross-section of the packing is thought to be sufficient clearance. Beveling or undercutting of edges and corners should be provided on rods and bores.

To prevent over-tightening and to ensure automatic, controlled wear take-up, as well as to allow a fixed stuffing-box length, spring biasing can be used, Fig. 51. A spring bias of 5 lb per linear inch of mean ring circumference for plain V-rings, or 10 lb per inch for Vee-Dam rings, Fig. 50, is usually recommended. Longer, more predictable packing life is thus obtained.

RUBBER U-CUPS: Another commonly used lip-type packing in molded synthetic rubber form is the so-called U-cup, Fig. 52. Like the V-ring, it has certain applications for which it is best suited. One advantage is its low friction in relatively low-pressure applications.

If materials involved are equivalent, friction in molded seal is a function of seal contact pressure and contact area. Two components of contact pressure are the internal strain energy of the seal and the applied fluid pressure. A lip-type seal, such as a U-cup, has less strain energy than a compression-type, such as an O-ring. Hence, in the pressure range up to about 175 psi, the larger frictional component is provided by the internal energy of the seal itself, and overall frictional resistance is low. As pressures go above this range, system pressure becomes the dominant component, and larger contact area of the lip-type seal produces greater total friction. Thus, in low-pressure systems where friction is important, lip-type seals such as U-cups may be preferred over O-rings.

U-cups have another advantage in their ability to withstand foreign-particle contamination where the operating fluid cannot be kept clean. O-rings are more susceptible to effects of such contamination because of their sealing-surface geometry. Any kind of packing, however, should be protected from outside contamination, where necessary, with a wiper ring.

U-Cup Application: A rod surface finish of 16 microinches is recommended, with not more than 0.003-in. radial clearance between back-up follower and shaft. The nose of the pedestal support ring should be rounded to avoid cutting packing, Fig. 53.

Susceptibility to extrusion normally limits use of rubber U-cups to pressures under 1000 psi in hydraulic applications. However, addition of a leather back-up ring will allow pressures to 2000 psi. The rubber U-cup has flared sidewalls which create an interference fit and make it especially adaptable to applications involving sudden pressure changes where instantaneous sealing is needed.

Rubber U-cups are especially adapted to low-pressure pneumatic applications. Preloading created by flared lip design insures good initial seal-

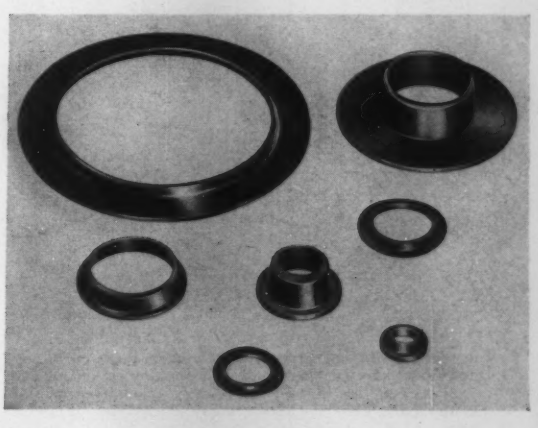


Fig. 54—Molded flange packings.

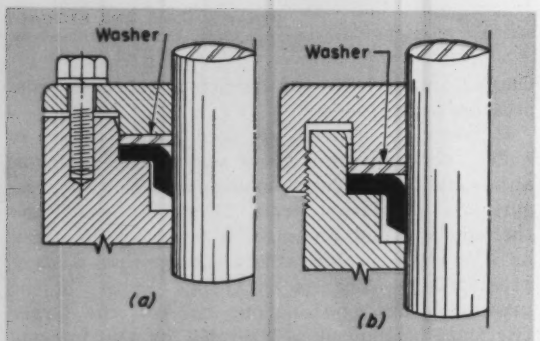


Fig. 55—Typical glands for flange packings showing, *a*, bolted and, *b*, threaded nut-type designs with back-up washers.

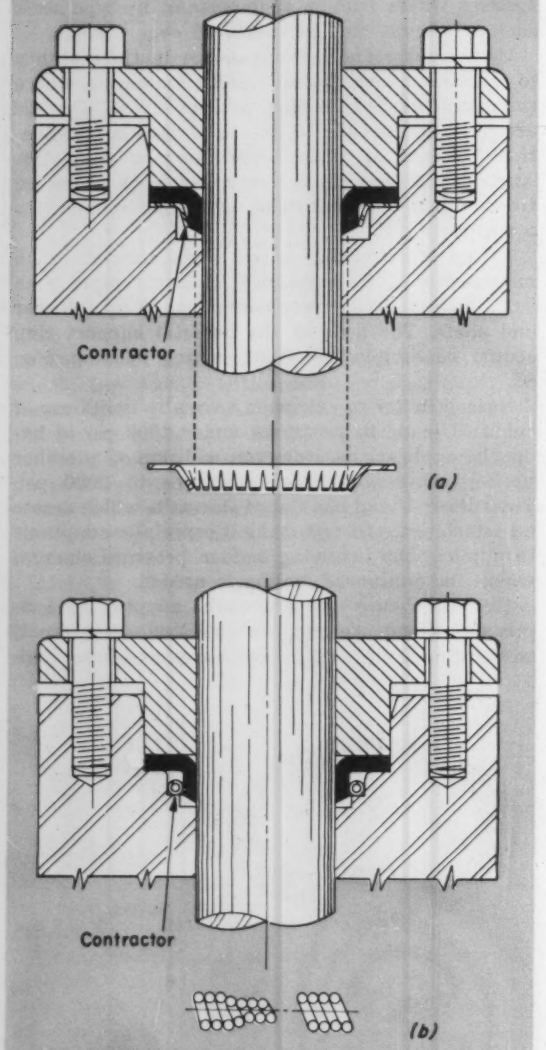


Fig. 56—Finger-type, *a*, and garter-type, *b*, contractors which may be employed to maintain contact between sealing lip of flange packing and rod or shaft.

ing. With proper lubrication, synthetic-rubber U-cups develop very little frictional resistance on piston rods. They also make good wiper rings for low-pressure service.

RUBBER FLANGE PACKINGS: Designed especially for shaft sealing, the rubber flange packing, Fig. 54, has a single sidewall that seals at its inner periphery to retain fluids under pressure or seal out foreign matter. It operates satisfactorily on a rotating shaft under low pressure, or as a reciprocating piston-rod packing under a wide range of pressures.

Synthetic-rubber flange packings are used primarily for rotary sealing and to exclude dust and dirt in hydraulic applications. For reciprocating motion, only small shafts and relatively low operating pressures are recommended. In pneumatic applications, reciprocating, oscillating, and rotary motions with low to moderate pressures may be sealed with rubber flange packings.

Usefulness of flange packings may be attributed to:

1. Low initial cost.
2. Simple machining required for packing recess and gland.
3. Small space required.
4. Simplicity of installation.
5. Adaptability to many applications.

Flange-Packing Application: Design should allow for assembling the rod or shaft through the flange packing before the gland is assembled, thus permitting the rod to center the packing properly.

Bolted or threaded glands are common, Fig. 55. Clearance between gland nose and recess bore should be close for a bolted gland, but may be greater for a threaded gland where the threads maintain concentricity. The outer end of the gland-nose recess should be chamfered to simplify packing installation.

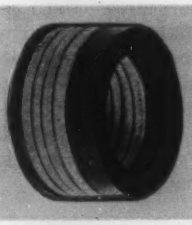
Close fit between shaft and gland, or a back-up washer, is recommended to prevent extrusion of the packing. A washer also prevents distortion caused by turning action of a threaded gland. When the gland is tightened on packing to develop a fluid-tight seal at the flange, compression not exceeding 25 per cent of packing thickness is suggested.

The packing recess should be of sufficient depth to prevent packing lip from contacting the bottom of the recess. Not less than 1/16-in. clearance for the packing lip is recommended. Diameter of the packing recess should allow clearance around the packing lip of about 15 to 25 per cent of packing thickness to permit full access for the pressurized fluid, to prevent binding, and to simplify assembly. The corner on the packing-recess shoulder should be broken to prevent cutting of packing.

Contractors, sometimes employed with flange packings to maintain contact between sealing lip and rod or shaft, are of metal, rubber, or other suitable material. Three common metal types are the finger type, garter or coiled spring, and solid spring, Fig. 56.

Available space, required tension, and size and firmness of packing determine type and characteristics of the contractor. Appropriate grooves or ledges must be designed into recesses to hold garter or solid-spring types.

Leather Packings



Mechanical leather packings have operated successfully against pressures ranging from a few ounces up to 50,000 psi. In special applications, pressures as high as 140,000 psi have been contained.

Processing of the leather can be varied to suit special demands of the application. Firmness of the packing, for example, can be controlled through tannage and impregnation. For extremely low-pressure sealing, a flexible tannage of leather impregnated with oil, grease, soft wax, or synthetic material is commonly employed. Firmer leather and harder impregnating materials are used for higher pressures.

Common liquids and gases that can be sealed effectively by mechanical leather packings include:

1. Air
2. Alcohol
3. Aqueous liquids
4. Gasoline
5. Oils
6. Solvents
7. Synthetic hydraulic fluids
8. Vacuum
9. Water

Sub-zero temperatures do not affect leather packings adversely. Almost all leather packings can be used from −30 to 150 F, and special forms are available for use from −70 to 210 F. Excessively high temperatures, such as are encountered on heated platens and in steam-jacketed cylinders, may cause trouble if proper insulation is not employed.

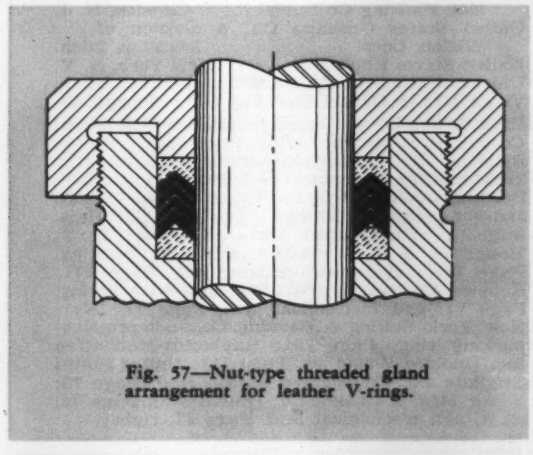


Fig. 57—Nut-type threaded gland arrangement for leather V-rings.

Leather-Packing Types: Three general forms of mechanical leather packings are available for dynamic sealing of reciprocating and rotating shafts:

1. V-rings
2. U-cups
3. Flange Packings

In addition to these standard molded types, washers or anti-extrusion rings are also available.

LEATHER V-RINGS: In hydraulic service, leather V-rings are adaptable to either rotary or reciprocating motion. They can be used singly, or in nested sets of three to five for low to high pressures, Fig. 57. When proper adapters are employed, tolerances are less critical than with other packing types. Spring-loading may be used to provide automatic take-up as a means of compensat-

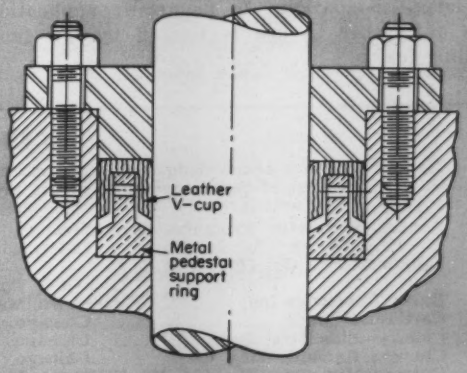


Fig. 58—Typical leather U-cup installation using bolted gland.

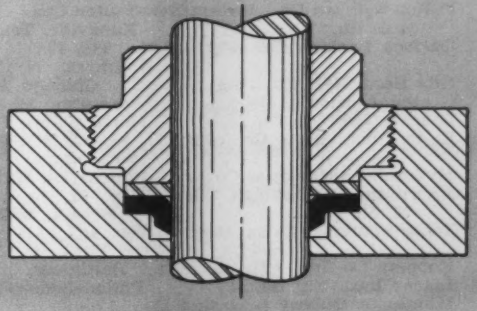


Fig. 59—Screw-type threaded gland design for leather flange packing.

ing for wear. Sets of leather rings alternated with synthetic-rubber V-rings and adapters are available for low to medium-pressure applications.

In high-pressure pneumatic service, leather V-rings provide long wear and excellent abrasion resistance, whether used singly or in nested sets. They are normally used for reciprocating applications, but are found in some rotary service.

LEATHER U-CUPS: Design considerations for leather U-cups are similar to those described for rubber U-cups in a preceding section. Since leather U-cups do not normally have a preloading flare, however, design success depends on the method of supporting and aligning the packing to prevent parallel legs from tipping away from sealing surfaces. A firm support that allows side legs freedom to seal is the pedestal ring, Fig. 58. Clearance on each side of pedestal should be approximately 25 per cent of leather thickness. At least ⅛-in. clearance should be allowed between legs and the end of the recess. A flax ring may be used effectively with U-cups too small for a metal pedestal ring.

In hydraulic service, the leather U-cup is best adapted to slow-speed reciprocating applications in large installations. In pneumatic applications, use of leather U-cups is limited by low initial sealing forces.

LEATHER FLANGE PACKINGS: Discussion of design considerations for rubber flange packings presented in a previous section also applies to leather flange packings, Fig. 59. In addition, as with other leather packings, extrusion and abrasion resistance is very good, and is not affected by sub-zero temperatures. Used primarily for sealing rotating shafts, leather flange packings also serve as wiper rings on reciprocating rods. They are not recommended for high pressures or large diameters. Recommended gland clearances are approximately 1/32-in. on the OD and ⅛-in. at end of beveled lip. Garter springs may be used as with rubber flange packings.

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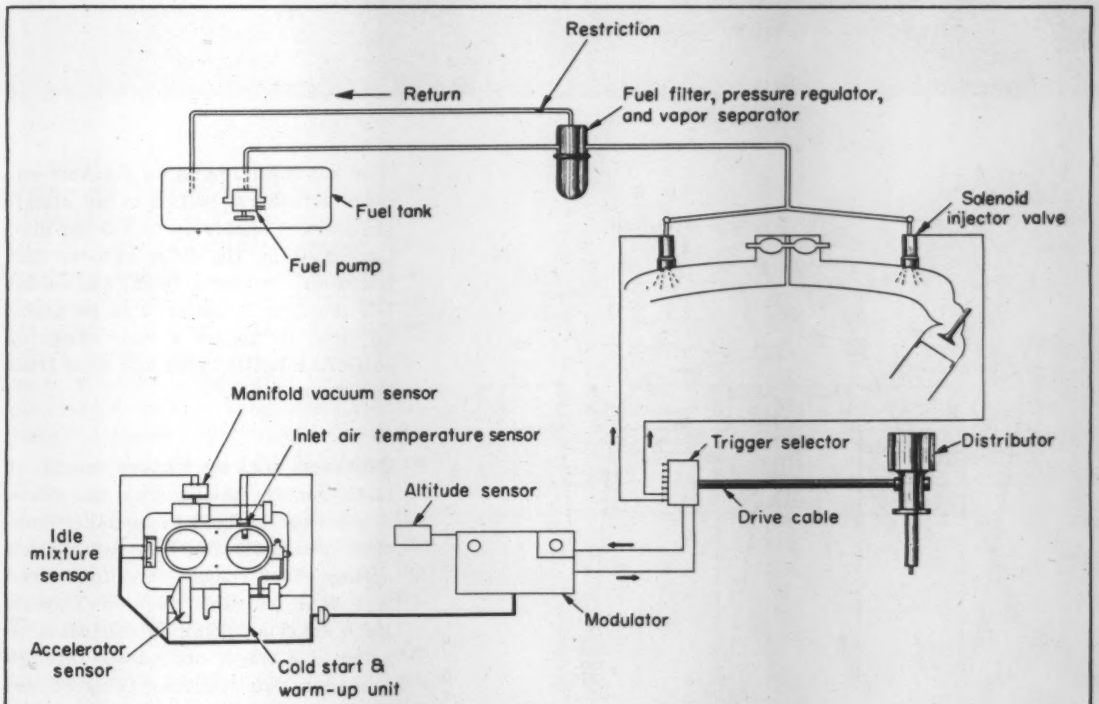
Electrical Pulses Meter Engine Fuel

A new fuel-injection system, designed as optional equipment for luxury models of the 1958 Chrysler Corp. cars, is electronically controlled. A transistor-equipped electronic modulator about the size of a 3 by 5-in. file-card box regulates fuel distribution to each cylinder. Located in front of the radiator, the modulator receives electric signals from various sensing units mounted in and around the engine. From these signals representing variations in engine temperature, throttle position, air temperature, engine load and altitude, the modulator automatically calculates engine fuel requirements for all driving conditions.

In operation the modulator unit lengthens or shortens an electrical pulse according to sensing-signal information. Each pulse is then sent out to open the injector valves long enough for the proper amount of fuel to be metered into the cylinders. Frequency of the pulse is determined by engine speed so that fuel is injected for each power stroke of the pistons. Pulses are 0.001-sec in duration.

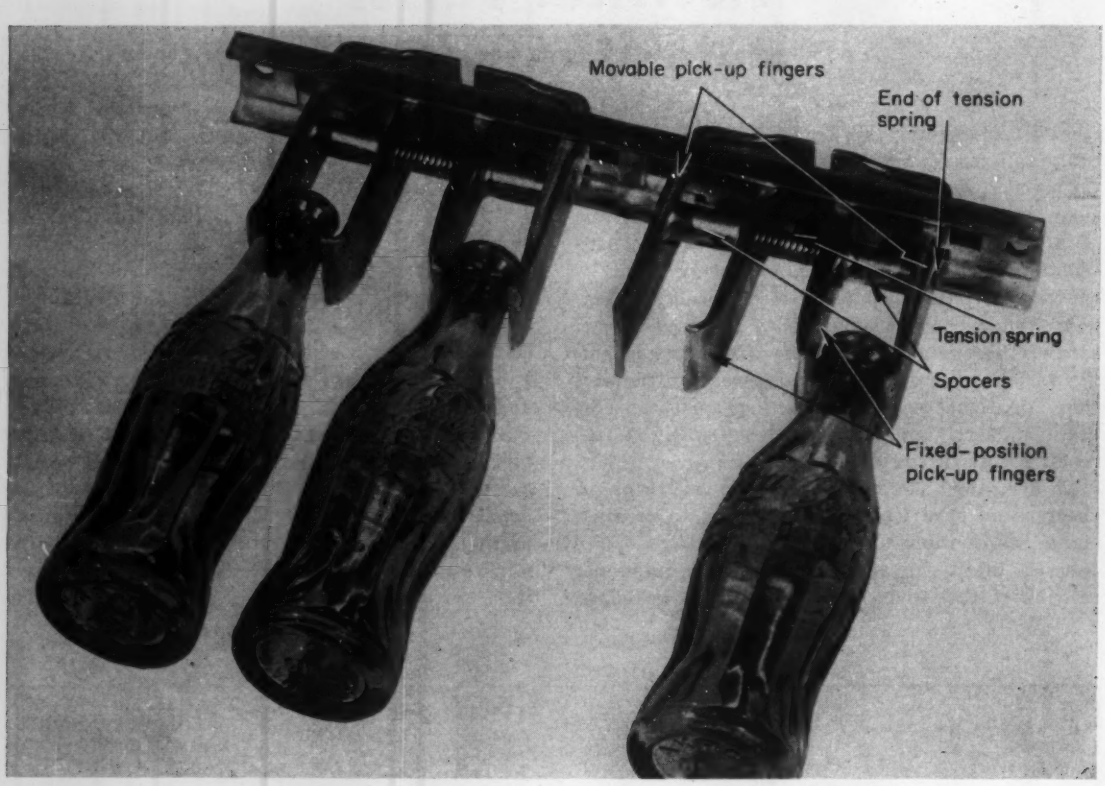
Gasoline is pumped from the tank into pipelines which travel along the top of the engine to serve both banks of cylinders. A key part of the fuel supply system is a new electric-motor-driven fuel pump submerged in the gasoline tank. As a precaution against flooding, the fuel pump motor will not start until the engine is being started and will not operate when the engine is stopped.

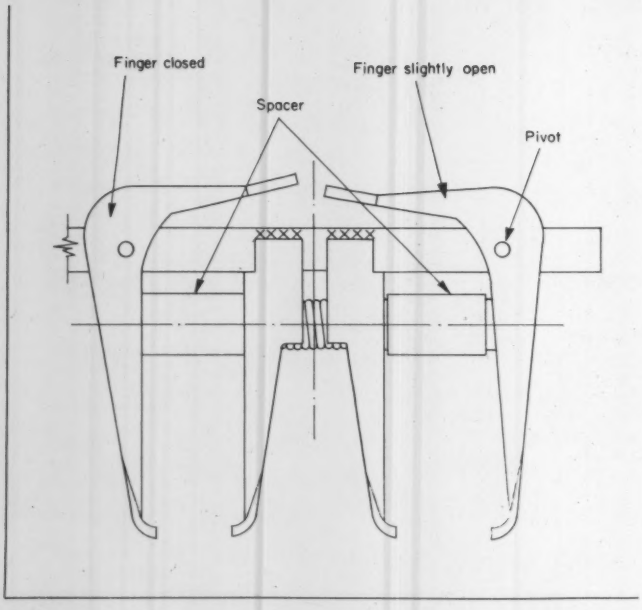
To keep dirt or metal particles out of the fuel pipe-line, an extremely fine filter is used which catches anything larger than 5 millionths of an inch. In addition, there is a magnetized wire spring in the pressure-regulator filter that captures any minute metal particles which might pass through the filter.



Injection Timing and Injector Actuating Elements

Spring-Loaded Metal Fingers

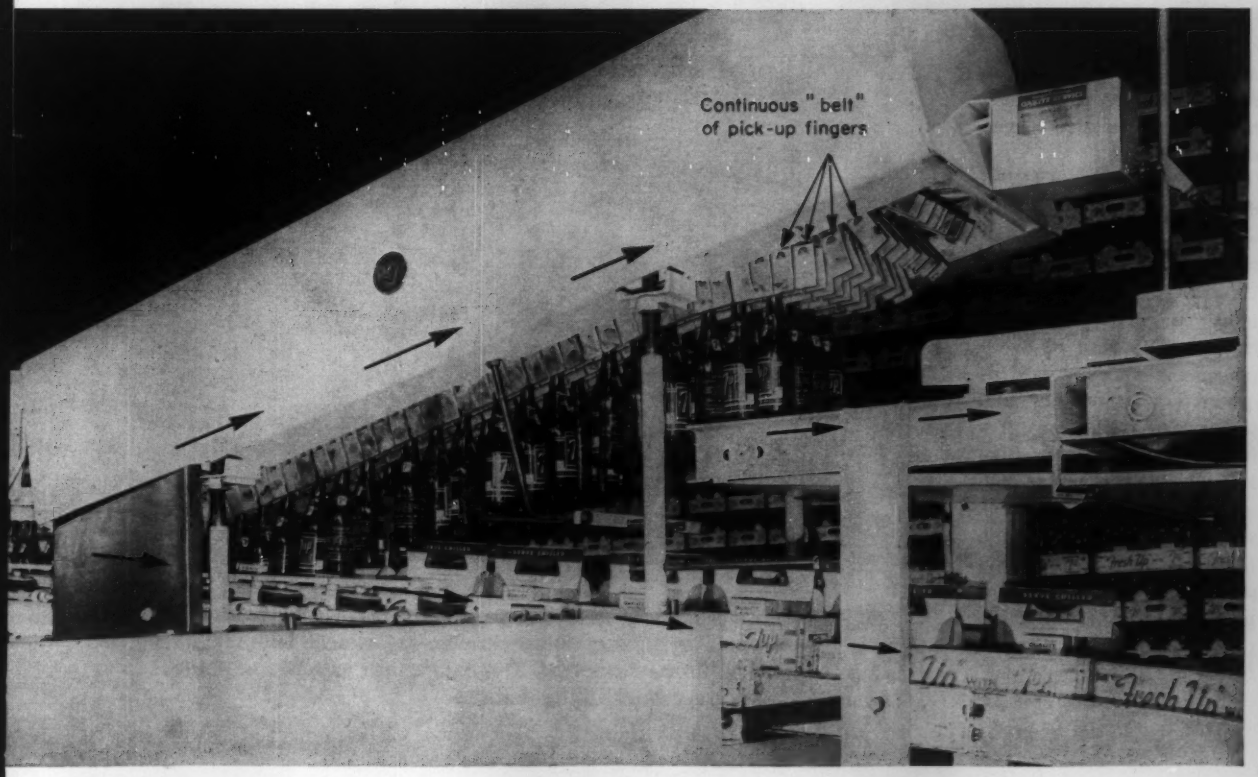




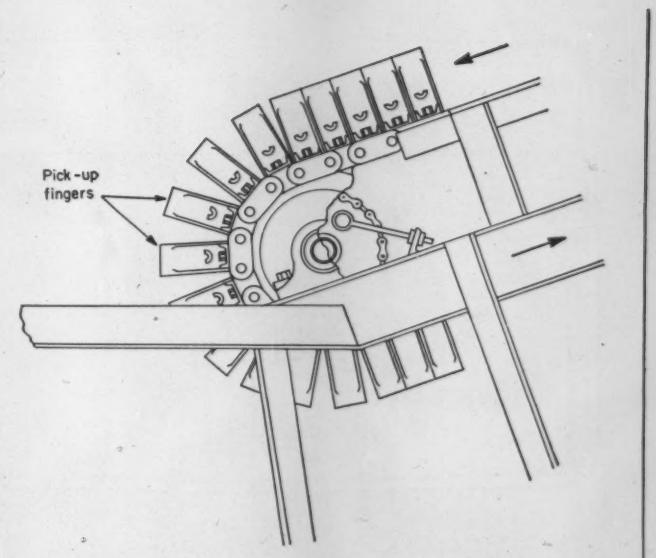
New automatic uncasing machine unloads soft-drink bottles of all standard sizes at speeds up to 500 per min. Developed by the RCA Theater and Industrial Products Dept., the model 7-U machine is designed to be easily adjusted to uncase a wide range of soft-drink bottle types and sizes from half-depth cases.

Overhead pick-up fingers made of metal remove bottles from the cases. A four-bottle holder assembly consists of a mounting bar, two tension springs, four spacers, and four fixed and four movable pick-up fingers. Each tension spring is connected to a movable finger and passes through a spacer, two stationary fingers, another spacer, and on to another movable finger.

Uncase Bottles at High Speed



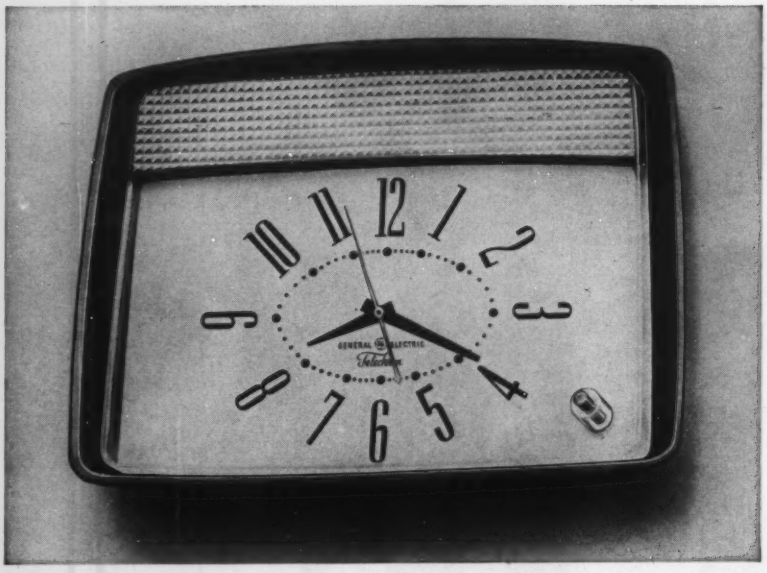
Automatic feeding of the machine with cases of empty bottles is accomplished with a conveyor belt arrangement. This conveyor moves at the same speed as a series of overhead pick-up finger assemblies, which are connected together into a continuous "belt." As the bottles move in between the spring-loaded pick-up fingers, pick-up cams open the adjustable fingers slightly until the bottle necks are centered between the fingers. Then the bottles are grasped around the neck. At this point the case-carrying conveyor belt moves down a slight incline while the bottles are lifted upward from the cases by the fingers. The bottles are carried forward to the top of the uncasing machine and are automatically released on another conveyor belt which goes to a washing machine.



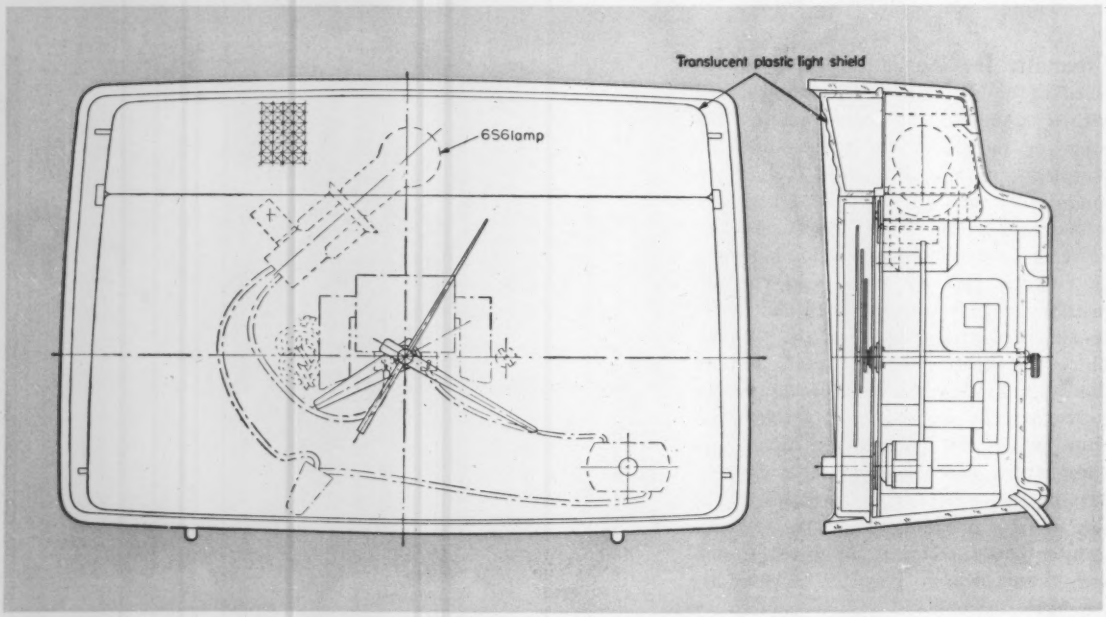
Clock Has Built-In Night Light

Lite-Time, a new General Electric - Telechron clock designed for kitchens or bathrooms, has an illuminated face that also serves as a night light.

No. 6S6 lamp used in the design is a 155-v bulb which has a 10-yr life expectancy if operated continuously at 115 v. The more common 7C7, 115-v lamp can be used as a replacement and meets Underwriters Laboratory Inc. temperature - rise requirements. Clock temperature is held below a reasonable value through the use of a foil reflector around the lamp and a series of louvers in the lower and upper back of the clock which provide required ventilation.



The translucent plastic light shield is designed to provide the correct brightness balance between the amount of light passing through the shield and the light being transmitted to the clock dial. The light shield material is Koppers "Evenglo" polystyrene, which is light stable.



Designing Cam Profiles

with digital computers

By HANS JEANS
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WITH THE ADVENT of electronic computers and automatically controlled machine tools, time and effort required to design and produce plate cams can be considerably reduced. The very nature of high-speed calculation requires a precise definition of the mathematical relationship of various parameters in cam design. Assuming that a point on the pitch curve is defined in polar co-ordinates (R, Φ), it is necessary to express the corresponding point (r, ϕ) on the cam profile as a function of R and Φ so that r and ϕ can be readily calculated. The derivation of such a function and the programming techniques required for an electronic computer are discussed in this article.

Cam-Profile Formulas: The design steps commonly used in the graphical method of deriving a cam profile are: 1. Draw the pitch curve. 2. Draw a series of circles, with radii equal to cam-follower roller radius, and centers on the pitch curve. 3. Draw an envelope to these circles. The result-

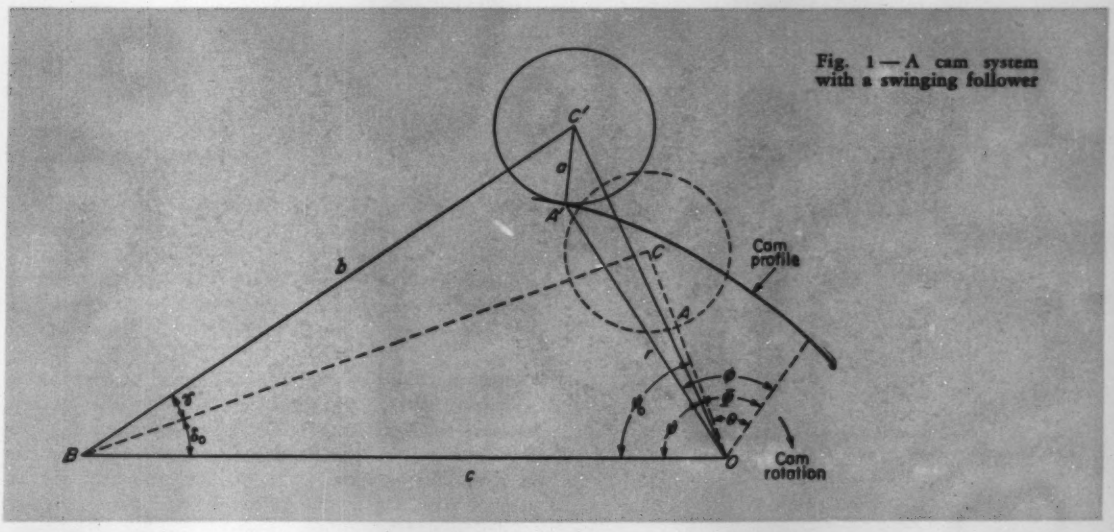


Fig. 1 — A cam system with a swinging follower

ing envelope is the required cam profile. In mathematical terms, this cam profile is the envelope of the family of circles with radii equal to a and centers located on the pitch curve.

This family of circles is represented by

$$r^2 + R^2 - 2rR\cos(\phi - \Phi) = a^2 \qquad (1)$$

The relationship of these and other symbols is depicted in Fig. 1 and 2. Since R is a function of Φ, the latter is the parameter for this family of circles. With r and ϕ independent of Φ, differentiating Equation 1 partially with respect to Φ gives the following equations:

$$2R\frac{dR}{d\Phi} - 2r\frac{dR}{d\Phi}\cos(\phi - \Phi) - 2rR\sin(\phi - \Phi) = 0$$

or

$$R\frac{dR}{d\Phi} - r\frac{dR}{d\Phi}\cos(\phi - \Phi) - rR\sin(\phi - \Phi) = 0 \qquad (2)$$

Elimination of R, $dR/d\Phi$ and Φ from Equations 1 and 2 gives the envelope of the family of circles, i.e., the cam profile in terms of r and ϕ.

However, for purposes of calculation, it is not necessary to derive the explicit expression involving r and ϕ. It would be much easier to eliminate $\sin(\phi - \Phi)$ and $\cos(\phi - \Phi)$ from Equations 1 and 2 and derive an expression for r in terms of R and $dR/d\Phi$.

From Equation 1,

$$\cos(\phi - \Phi) = \frac{r^2 + R^2 - a^2}{2rR}$$

If this value of $\cos(\phi - \Phi)$ is substituted in Equation 2,

$$\sin(\phi - \Phi) = \frac{1}{R}\frac{dR}{d\Phi}\frac{R^2 + a^2 - r^2}{2rR}$$

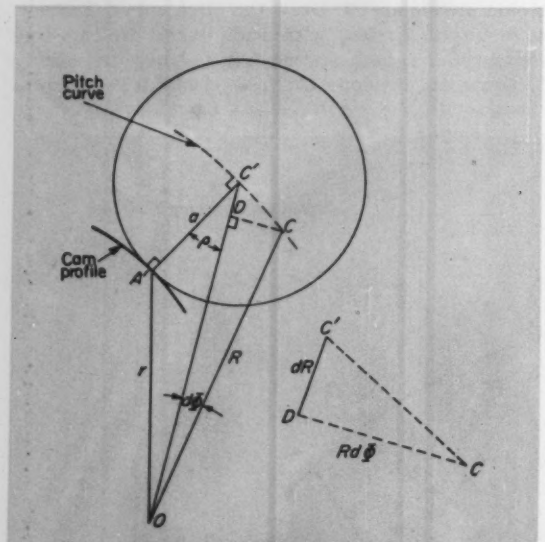


Fig. 2—Geometric relationship between r and R

By the trigonometric identity $\sin^2(\phi - \Phi) + \cos^2(\phi - \Phi) = 1$, or

$$\left(\frac{1}{R}\frac{dR}{d\Phi}\right)^2\left(\frac{R^2 + a^2 - r^2}{2rR}\right)^2 + \left(\frac{r^2 + R^2 - a^2}{2rR}\right)^2 = 1$$

the following expression can be derived:

$$r^2 = a^2 + R^2 \pm \frac{2aR}{\sqrt{1 + \left(\frac{1}{R}\frac{dR}{d\Phi}\right)^2}} \qquad (3)$$

Sign of the last term in Equation 3 reflects the two possible envelopes of the family of circles. When the follower roller circumscribes the cam, the minus sign should be adopted. With r known, $(\phi - \Phi)$ and ϕ can be easily calculated. Thus, the cam profile is defined by a table of values for ϕ and corresponding r.

Once Equation 3 is found, it is obvious that

$$\frac{1}{\sqrt{1 + \left(\frac{1}{R}\frac{dR}{d\Phi}\right)^2}}$$

is the cosine of the angle $A'C'O$ or ρ in Fig. 2. Assuming that the follower center moves from C to C', then line segment $\overline{OC} = \overline{OD} = R$, segment $\overline{DC'} = dR$ and angle $COC' = d\Phi$. Thus line segment $\overline{CD} = Rd\Phi$. Since radius of follower roller, $\overline{A'C'}$, is normal to the cam profile, and the cam profile and pitch curve have the same curvature at points A' and C', respectively, line $\overline{A'C'}$ is normal to the pitch curve. In other words, angle $A'C'C = \pi/2$.

The triangle CDC' may be considered a right triangle with angle $CDC' = \pi/2$. Being complements of the same angle $CC'D$, angle $C'CD = \rho$. Thus,

$$\cos\rho = \frac{\overline{CD}}{\overline{CC'}} = \frac{Rd\Phi}{\sqrt{(Rd\Phi)^2 + (dR)^2}}$$

$$= \frac{1}{\sqrt{1 + \left(\frac{1}{R}\frac{dR}{d\Phi}\right)^2}}$$

Programming for Computer: To determine a cam profile, R and Φ must be calculated from the angular displacement γ of the follower. If it is assumed that the cam system employs a swinging follower, the type of motion (acceleration, deceleration or constant velocity) of the follower determines γ at any instant, Fig. 1. With the cam rotating at a constant angular velocity, γ can be expressed as a function of θ, the angular displacement of the cam.

Suppose it is required to accelerate the swinging follower away from the cam shaft center with a change in angular velocity from ω_0 to ω_1 deg per sec in t sec. If it is assumed that the follower has a cycloidal motion with acceleration varying as a sine function in the interval from 0 to 180 deg,

the following expression can be derived:

$$\gamma = \frac{t(\omega_0 - \omega_1)}{360} \sin\left(180\frac{\theta}{\beta}\right) + \tau\frac{\theta}{\beta} \quad (4)$$

This formula applies to acceleration for $\omega_1 > \omega_0$; deceleration for $\omega_0 > \omega_1$; and constant velocity for $\omega_0 = \omega_1$. The angular velocity of the follower is assumed to be positive for rotation away from the cam center and negative for rotation toward the cam center.

The total angular displacement τ of the follower cannot be arbitrarily set since it is equal to $\frac{1}{2}(\omega_0 + \omega_1)t$. However, it is possible to circumvent this difficulty by subdividing the time interval t into two intervals, t_1 and t_2. To achieve a final velocity ω_1, it is necessary to accelerate for t_1 sec to an intermediate velocity ω' and decelerate for the following t_2 sec. Thus the angular displacement of the follower is τ_1 in t_1 sec and τ_2 in t_2 sec. These variables satisfy the following set of equations:

$$\tau_1 + \tau_2 = \tau \quad (5)$$

$$\frac{1}{2}(\omega_0 + \omega') = \tau_1/t_1 \quad (6)$$

$$\frac{1}{2}(\omega' + \omega_1) = \tau_2/t_2 \quad (7)$$

The angular displacement τ of the follower is determined by its position at the end of the interval. For example, with R defined for that position, the angle δ_1 subtended by sides b and c can be calculated, and $\tau = \delta_1 - \delta_0$. The value of τ will be negative when δ_0 is greater than δ_1.

With τ, t_1, t_2, ω_0 and ω_1 known, it is possible to solve these equations for ω', τ_1 and τ_2. If it is desirable to select values for t_1 and t_2, then Equation 5 can be replaced by

$$t_1 + t_2 = t \quad (8)$$

and Equations 6, 7 and 8 solved for ω', t_1 and t_2. With the determination of the total angular displacement and final velocity of the follower in time interval t, Equation 4 can be used to calculate γ for a cam displacement θ.

In a swinging-follower cam system, the points (R, Φ) on the pitch curve can be derived by triangulation. By the cosine law,

$$R^2 = b^2 + c^2 - 2bc\cos(\delta_0 + \gamma) \quad (9)$$

The angle $\Phi = \theta + \psi_0 - \psi$ with

$$\psi_0 = \sin^{-1}\frac{b\sin\delta_0}{R_0}$$

and

$$\psi = \sin^{-1}\frac{b\sin(\delta_0 + \gamma)}{R}$$

To calculate r, the value of $dR/d\Phi$, which can be expressed as $(dR/d\theta)/(d\Phi/d\theta)$ is needed. Differentiation of Equation 9 with respect to θ gives

$$2R\frac{dR}{d\theta} = 2bc\sin(\delta_0 + \gamma)\frac{d\gamma}{d\theta}$$

or

$$\frac{dR}{d\theta} = \frac{bc}{R}\sin(\delta_0 + \gamma)\frac{d\gamma}{d\theta}$$

where $d\gamma/d\theta$ can be readily found by differentiating the expression for γ. The term $d\Phi/d\theta$ is derived by differentiating $\Phi = \theta + \psi_0 - \psi$ with respect to θ. The result is

$$\frac{d\Phi}{d\theta} = 1 - \frac{d\psi}{d\theta} = 1 - \frac{d}{d\theta}\sin^{-1}\frac{b\sin(\delta_0 + \gamma)}{R}$$

$$= 1 - \frac{b}{R\cos\psi}\left[\cos(\delta_0 + \gamma)\frac{d\gamma}{d\theta} - \frac{1}{R}\sin(\delta_0 + \gamma)\frac{dR}{d\theta}\right]$$

$$= 1 - \frac{b}{R\cos\psi}\left[\cos(\delta_0 + \gamma) - \frac{bc}{R^2}\sin^2(\delta_0 + \gamma)\right]\frac{d\gamma}{d\theta}$$

Once R and $dR/d\Phi$ are found, r is calculated by means of Equation 3. The angle $(\phi - \Phi)$ can be derived from Equation 1. However, for calculation by computer and automatic determination of sign, $\phi - \Phi$ is computed from $\sin^{-1}[(a\sin\rho)/r]$. Since

$$\sin\rho = \frac{\frac{1}{R}\frac{dR}{d\Phi}}{\sqrt{1 + \left(\frac{1}{R}\frac{dR}{d\Phi}\right)^2}}$$

Nomenclature

A, A' = Point of contact of roller with cam
a = Radius of follower roller, in.
B = Position of follower-arm pivot
b = Length of follower arm ($\overline{BC}$, $\overline{BC'}$), in.
C, C' = Position of follower center
c = Distance from cam center to follower-arm pivot ($\overline{OB}$), in.
O = Cam-shaft center
R_0, R = Radius measured from cam-shaft center to follower-roller center ($\overline{OC}$, $\overline{OC'}$), in.
r = Radius of cam ($\overline{OA}$, $\overline{OA'}$), in.
β = Total angular displacement of cam for a complete event, deg
γ = Angular displacement of follower arm measured from its initial position, deg
δ_0, δ = Angle subtended by the follower arm and the line $\overline{OB}$, deg
θ = Angular displacement of cam measured from a space fixed reference, deg
ρ = Angle $A'C'O$, deg
τ = Total angular displacemont of follower arm for a complete event, deg
Φ = Angular displacemnt of cam measured from a line joining cam and follower-roller center, deg
ϕ = Angular displacement of cam measured from a line joining cam center and contact point, deg
ψ_0, ψ = Angle subtended by $\overline{OB}$ and the line joining cam and follower-roller center, deg

the sign of sin ρ is determined by that of $dR/d\Phi$, and, in turn, this determines the sign of $\phi - \Phi$. Thus, depending upon the sign of $dR/d\Phi$, $\phi - \Phi$ will be added to or subtracted from Φ to result in ϕ.

The process of calculating γ, R, Φ, r, and ϕ is repeated for increasing values of θ until $\theta = \beta$. Then the constants are changed and calculation for the next section of the cam profile continues. The values of ϕ in the tabulation are unevenly spaced and, therefore, cannot be used on an automatically controlled milling machine. Interpolation of cam radii for evenly spaced cam angles can also be programmed.

Conclusions: When a cam rotates at high speed and the motion of its follower is complex, it is essential to calculate the cam profile as precisely as possible. Equation 3, as derived above, provides a means for calculating r and, indirectly, ϕ. As long as an expression of R in terms of θ, such as Equation 9, can be derived from a given type of follower motion, it should be possible to calculate the various factors (R, Φ, $dR/d\Phi$, r, sin ρ, $\phi - \Phi$, and ϕ) step by step as illustrated by the cam system with a swinging follower.

Although the calculations are lengthy if performed manually, they can be done on an electronic digital computer in a matter of seconds for each pair of r and ϕ. Other considerations, such as analyses of pressure angle, dynamic loads, and minimum radius of curvature, can be included in the computer program for adjustment of various parameters. The cam radii are interpolated for evenly spaced ϕ values. The output of the computer—a table of ϕ and r—can be punched into a paper tape for use on an automatic milling machine.

Calculations on a digital computer can be facilitated by the selection of a proper expression for the value to be calculated. For example, whenever possible, it is easier to find an angle by the sine law than by the cosine law—assuming that another angle and the corresponding sides in the triangle are known. With an arcsine routine available, the calculation of an angle by the sine law takes fewer steps and probably less time. In programming a computer, the programmer should attempt to minimize the number of steps or instructions in the program, the amount of working storage space for constants and intermediate results, and the time required to run the program. Since it may not be possible to minimize all these factors, the program sequence will be determined by the characteristics of the computer used, i.e., storage capacity, calculation speed, etc.

Practical Tips for Designing Electric Heating Elements

PROVIDING trouble-free performance and long life from electrical heating elements depends not only upon using the correct resistance alloy, but also on proper design of the element itself, according to Hoskins Mfg. Co., Detroit, Mich.

As a guide for designing electrical heating-elements, Hoskins engineers suggest the following design "do's and don'ts."

1. Don't design a device for 115 volts and expect to wire it for 230 volts, too. Start the design with the 230-volt unit in mind. Working out a good 230-volt heating element for a small device is difficult.

2. Remember that 1 per cent excess voltage will cause 2 per cent excess wattage.

3. To draw more power for a given heating element design, reduce the length or increase the diameter of the wire.

4. Where highly accurate wattage value is needed, make proper allowance for rise in resistance with temperature.

5. Allow sufficient space for the element to expand and contract. If an element must be anchored between terminals, check to make sure that warpage or "creeping" will not cause trouble.

6. Try to keep the helical-coil-arbor to wire-size ratio under 10. Larger ratios produce a coil which is flimsy and difficult to make.

7. If twisted "tails" are used to connect the heating element, don't cut off the loop at the end. The resultant loose strands sometimes pick up current from the terminal and carry it into the element.

8. Weld, braze or spot-weld joints between alloy wire and terminals. Pressed, or pressure joints are also satisfactory, but should be carefully tested.

9. Don't use pressure joints between the alloy wire and brass, if the brass will reach a temperature of more than 300 deg F. Beyond this range the zinc will oxidize and form an insulating film.

10. If a pressure joint is used, stretching or yielding of the clamping device sometimes causes loose-contact trouble. It is better to place the alloy wire between two nuts than one.

11. If alloy wire is wrapped around terminal, follow a clockwise direction. Don't lap the wire. The clamping pressure may cut it.

12. Mount heating elements so that the heat "flows" as easily as possible into the work to be heated.

13. Don't expose a hot 80-20 nickel-chromium alloy wire to sulfur gases, particularly in a reducing atmosphere. Under these conditions, a 35-20 nickel-chromium-iron alloy offers greater durability, if operating temperatures are not excessive.

14. Don't expose a hot wire to dripping oil, oil spray, or to contaminating gases which are formed by some grades of asbestos or low-temperature magnesia insulation.

Basic design facts about Belleville Spring Washers

By W. M. HANNEMAN, Executive Engineer, Shakeproof Div.
Illinois Tool Works, Elgin, Ill.

IN 1867, the United States Patent Office issued to "Julien Francois Belleville, of Paris, in the Empire of France" a memorable patent on an improved "car-spring." The patent reads in part: "The object of this invention is to utilize the elasticity of metallic disks of a trunco-conical shape, that is to say, conical disks, which are intersected by a plane perpendicular to the axis of the cone. These disks are united in couples and are traversed in their centre by a bolt."

Over the years since this early development, the name Belleville has become a firmly established part of the language of engineering. It is now being used to identify a certain class of "trunco-conical" spring washers with specific design characteristics. In this sense, the meaning of the term is restricted and does not properly apply, as sometimes used, to all trunco-conical washers, many of which actually exceed the limitations for good spring washers of this shape. The purpose

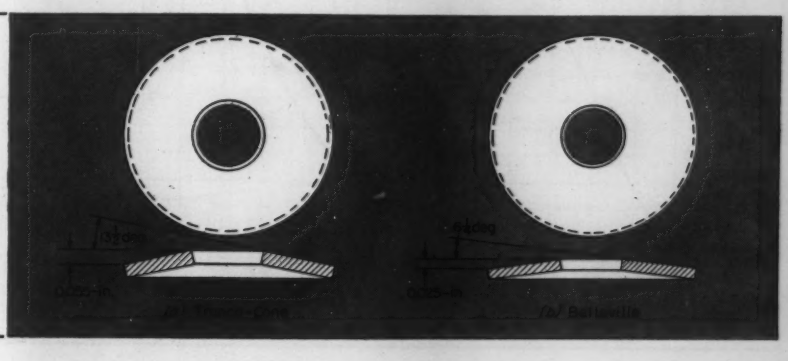


Fig. 1 — Trunco-conical washer designs for ¼-20 hex head screw. Proportions of design at *a* exceed the limitations of the Belleville spring form; those at *b* do not.

of this article is to clarify some of the basic design concepts and limitations of spring washers of the Belleville form.

Basic Design Relationships: In the text of Belleville's patent can be found these statements: "The springs I have described cannot be put into practical use unless they are made of certain dimensions and proportions which I have only found out and determined by numerous and repeated experiments." It then goes on to say that when the width of the rim of the washer is too great in proportion to the thickness, the disks get out of shape and suddenly reverse their shape. "It is by reducing the relations of the thickness and of the radius of the disk [width of the rim] to the proper proportion with respect to each other, that springs are obtained in which the resistance is proportionate to the load.

"Experience has shown me, first, that the deformation of the springs will be produced when the thickness is about one-fifth of the rim; second, that when the thickness is reduced to one-tenth or one-twelfth of the rim, a spring is produced, which no longer becomes misshapen, but of which the resistance is irregular and weak; third, that in order to obtain disks which will form good springs, that is, having a resistance proportionate to the weight or load, it is necessary that the proportion of the thickness of the disks to the rim should not sensibly exceed one-eighth, and may even be preferably below that figure.

"In order that the disks may always be compressed so as to form a solid block before exceeding the limit of their elasticity, thus avoiding all danger of their being injured or broken by an undue strain, it becomes necessary that their degree of conicalness, or the inclination given to the rim should not exceed one-tenth of the radius, whatsoever kind of metal be employed."

From this description, it would appear that the relationship of washer thickness to width of rim should be in the ratio of 1:5 and should not exceed 1:8. Also, the slope of the cone should be such that the relation of height of cone to width of rim should not exceed 1:10. This slope is in the vicinity of 5½ deg.

These findings seem to agree with results of numerous tests of various types of conical washers. If the overall height of the washer is excessive, much of this height is consumed by permanent set on application. Thus, a washer that is designed with greater height to increase the range of flexibility may, upon application, produce effects which are detrimental. These effects would not occur with a properly proportioned design.

Application Example: The pitfalls of designing such washers beyond their capacity is demonstrated by analysis of a typical trunco-conical washer construction used extensively by an automobile manufacturer.

Dimensions of the washer before use are, Fig. 1*a*: Material thickness, 0.053-in.; outside diameter, 0.695-in.; inside diameter, 0.223-in.; total height, 0.108-in.; height of cone, 0.055-in.; side angle of cone, 13½ deg.

Under compression to flat, the washer took a set of 0.030-in., the height of the cone was reduced to 0.025-in., and the side angle was reduced to 6¼

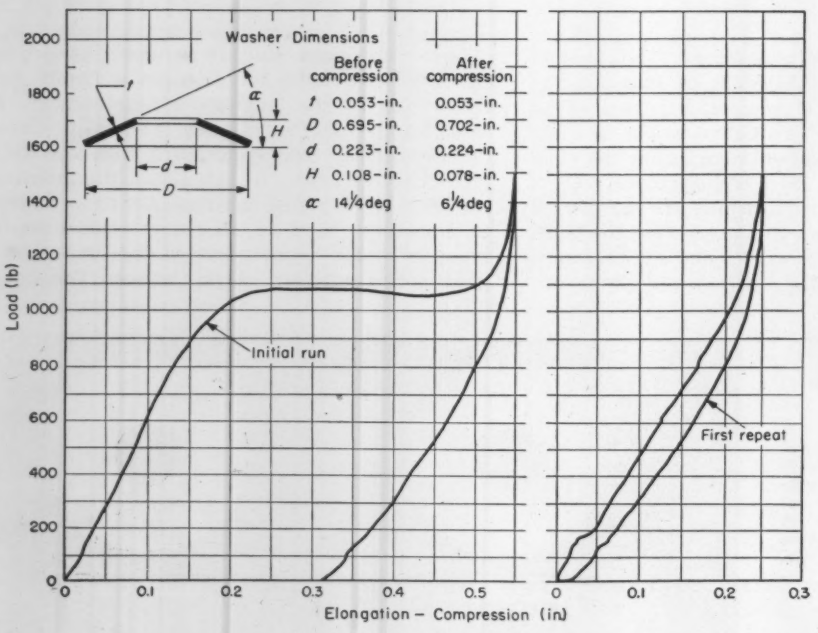


Fig. 2 — Load-deflection curves for washer design of Fig. 1*a*, showing effect of deformation on operating characteristics during initial and first-repeat load cycles.

deg. Had the washer been designed to this height originally, it would have more nearly met the conditions determined by Belleville.

Effect of direct compression of this washer is shown in Fig. 2. At a load at 1,000 lb the washer deflects 0.019-in. without permanent set. An additional load of 80 pounds brings the pressure beyond the elastic limit and the washer "gives" until the setting is completed. After this, very little deflection occurs under increased load as the washer is practically flat. The return curve shows the washer has taken a permanent set of 0.030-in.,

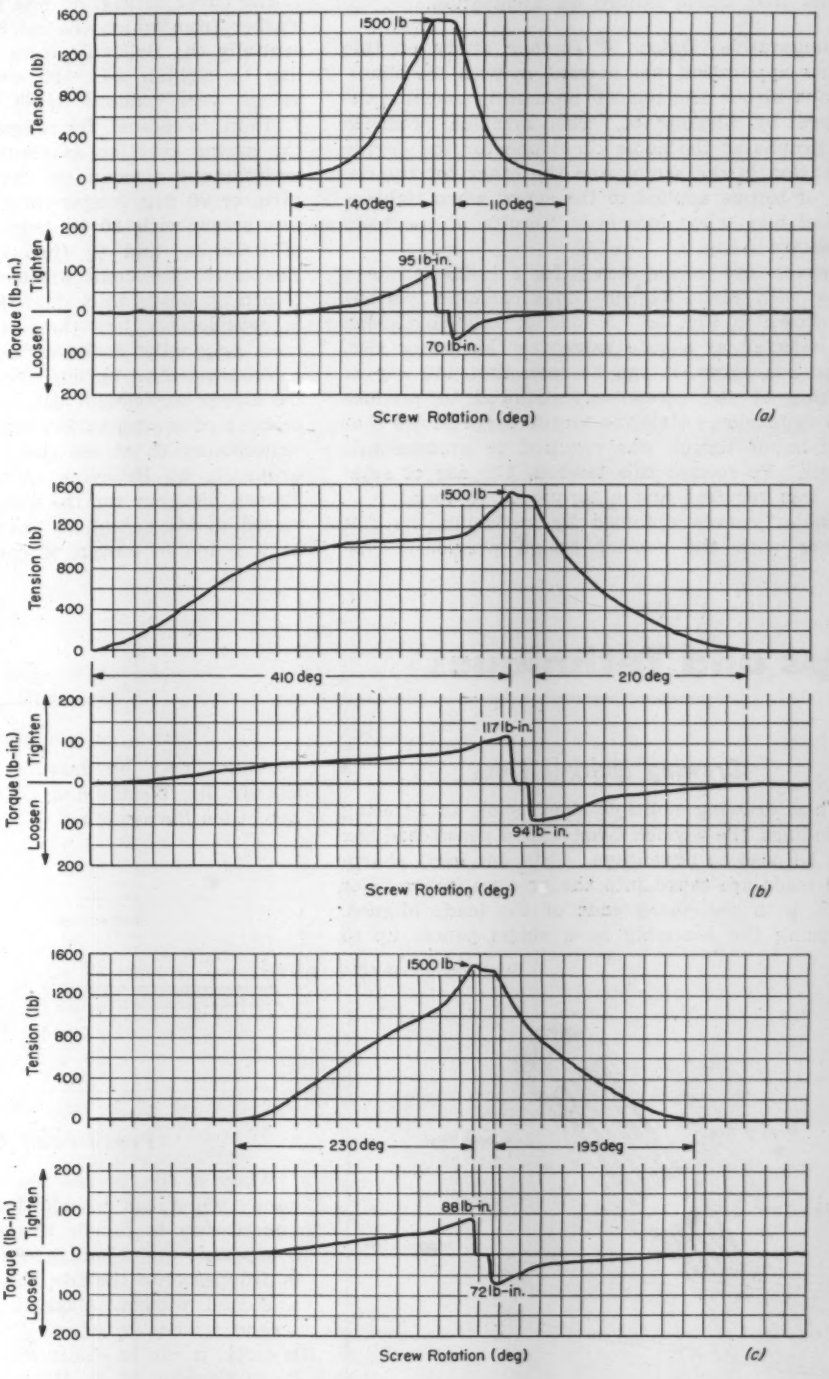


Fig. 3—Torque and tension curves for ¼-20 hex head screw with, *a*, plain washer; *b*, trunco-conical washer (Fig. 1*a*); and *c*, Belleville spring washer form (Fig. 1*b*).

which is more than one-half of the design height.

The "First Repeat" curve, Fig. 2, shows the resiliency after set and more nearly represents the true characteristics and limitations of a washer of this design. Thus, added cone height may give the washer the appearance of greater resiliency than it actually possesses, leading to strains that cause failure on application.

Comparative Data: A further study of this washer application was carried on with the simultaneous torque and tension measuring machine developed by Shakeproof. This machine produces two graphs at the same time: one for the degree of tension in the screw, and the other for the degree of torque applied to the screw when tightened and also when loosened. Results of the tests are shown in Fig. 3.

Tension and torque curves for a ¼-20 hex head screw with plain washer (both cadmium plated) are shown in Fig. 3*a*. A load of 1500 lb tension was selected as a safe value for this screw size. From this curve, it can be seen that 140 deg of rotation of the screw was required to produce 1500 lb tension. Also, the torque curve shows that 95 lb-in. of torque was required to produce this tension. To release this tension, 110 deg of rotation was required and a torque of 70 lb-in.

Similar curves obtained by replacing the flat washer with the conical design previously discussed (Fig. 1*a*) are given in Fig. 3*b*. The tension curve shows a give or setting action at approximately 1000-lb load. This action occurs at about 50 lb-in. applied torque. The curve flattens out during this setting action and again increases after the set is taken out of the washer. A rotation of 410 deg was required to produce 1500 lbs. tension, but only 210 deg to release it. A torque of 117 lb-in. was required to tighten, 94 lb-in. to loosen.

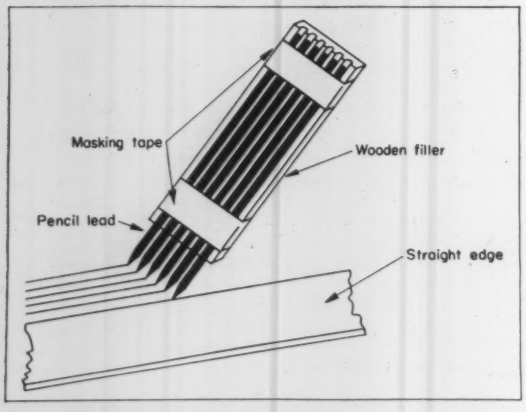
The curve in Fig. 3*c* was produced by a similar washer from which the set had been removed, essentially the Belleville form. It required only 230 deg to tighten and 195 deg to loosen. Torque values were reduced to 88 lb-in. to tighten and 72 lb-in. to loosen. By comparison, Figs. 3*a* and *c*, the spring reaction inherent in the cone washer maintains a tension on the screw for about ¼ turn, or 90 deg, longer than does the flat washer. The screw with 20 threads per inch has a pitch of 0.050-in., and ¼ turn is equal to 0.0125-in. Therefore, the cone washer has 0.0125-in. more return on usage than does the plain washer. This is considerably less than the 0.055-in. height of cone originally designed in the washer.

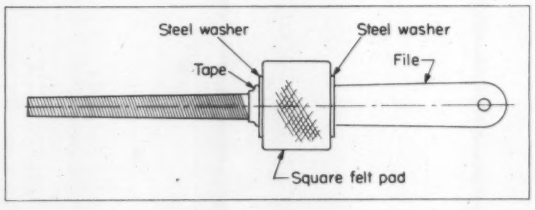
Trunco-conical spring elements can be designed for almost any height but, since there is a definite amount of spring-back available, it would appear unnecessary to exceed the proportions established originally by Belleville. Much credit is due this French designer for the excellent engineering disclosed in his patent 90 years ago. It still serves as a guide in design of conical spring elements.

Tips and Techniques

Drawing Multiple Lines

When drawing multiple lines, such as lettering guide-lines, the wooden filler from a pencil-lead box may be used to advantage. Six (or less) sharpened leads are taped into the grooves in the filler block, with the sharp ends of the leads aligned. By using the assembly as a single pencil, up to six lines may be drawn simultaneously.—B. R. BELOTE JR., *Westinghouse Electric Corp., Air-Arm Div., Glen Burnie, Md.*





Pencil-Point Cleaner

When a file is used for pencil sharpening, a handy wiper can be added to the file, making it unnecessary to handle two separate objects when sharpening and cleaning a pencil. A steel washer is dropped onto the file, then a felt pad, and then a second washer. Masking tape will retain the second washer in place. When the felt-pad wiper is dirty, it can be easily removed and discarded.—RAWL GERROW, M. E., *Milwaukee, Wis.*

Equations for Finding
TANGENT CIRCLES

By JAMES D. RUTTER
Jatkoe Machine Tool Engineering Co.
Detroit

DESIGN and layout frequently require finding the center of a circle that will be tangent to three other circles. Problems of this nature, often encountered in gear-train designs, may be readily divided into two separate groups, depending upon whether or not the three given circles are of the same diameter. For each case, one of two series of equations may be used for the solution. The relative location of the given circles to each other and to dimensioning reference lines will dictate which method to use.

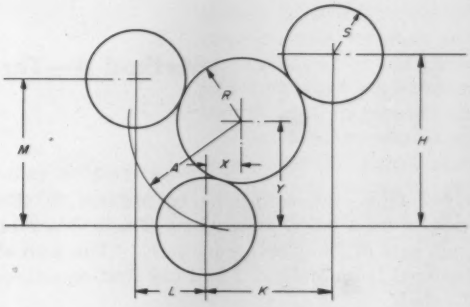
The equations in Methods 1 and 2 are for the solution of problems involving three equal-diameter circles. Methods 3 and 4 may be used where the given circles are of either equal or unequal diameters.

Method 1—Three Equal Circles

$$X = \frac{M(H^2 + K^2) - H(L^2 + M^2)}{2(HL + KM)}$$

$$Y = \frac{K(L^2 + M^2) + L(H^2 + K^2)}{2(HL + KM)}$$

$$R = (\sqrt{X^2 + Y^2}) - S$$



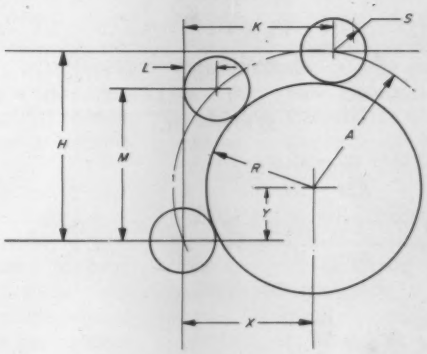
Method 2—Three Equal Circles

Basically the same equations as in Method 1, this version is used when dimensions K and L are on the same side of their common reference line.

$$X = \frac{M(H^2 + K^2) - H(L^2 + M^2)}{2(KM - HL)}$$

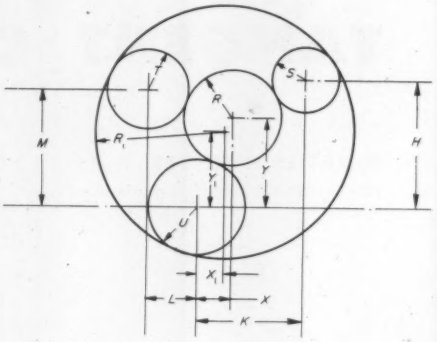
$$Y = \frac{K(L^2 + M^2) - L(H^2 + K^2)}{2(KM - HL)}$$

$$R = (\sqrt{X^2 + Y^2}) - S$$



Method 3—Three Unequal Circles

Equations required for unequal-diameter circles are somewhat more complicated and must be worked with more care regarding signs. In both Methods 3 and 4, if X is positive, it is to the right of the lower given circle. If Y is positive, it is above the lower given circle.



$$W = \frac{L(H^2 + K^2 + U^2 - S^2) + K(L^2 + M^2 + U^2 - T^2)}{2(HL + KM)}$$

$$G = \frac{M(H^2 + K^2 + U^2 - S^2) - H(L^2 + M^2 + U^2 - T^2)}{2(HL + KM)}$$

$$F = \frac{L(U - S) + K(U - T)}{HL + KM}$$

$$Z = \frac{M(U - S) - H(U - T)}{HL + KM}$$

$$A = 1 - F^2 - Z^2$$

$$B = U - WF - GZ$$

$$C = W^2 + G^2 - U^2$$

$$R = \frac{(\sqrt{B^2 + AC}) - B}{A}$$

$$R_1 = \frac{(\sqrt{B^2 + AC}) + B}{A}$$

$$X = G + ZR$$

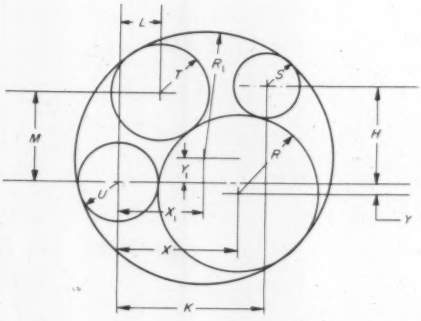
$$X_1 = G - ZR_1$$

$$Y = W + FR$$

$$Y_1 = W - FR_1$$

Method 4—Three Unequal Circles

Derived from the equations in Method 3, this variation is used when dimensions K and L are on the same side of their reference line. The sign of L is changed from Method 3 and the first equations are affected.



$$W = \frac{K(L^2 + M^2 + U^2 - T^2) - L(H^2 + K^2 + U^2 - S^2)}{2(KM - HL)}$$

$$G = \frac{M(H^2 + K^2 + U^2 - S^2) - H(L^2 + M^2 + U^2 - T^2)}{2(KM - HL)}$$

$$F = \frac{K(U - T) - L(U - S)}{KM - HL}$$

$$Z = \frac{M(U - S) - H(U - T)}{KM - HL}$$

$$A = 1 - F^2 - Z^2$$

$$B = U - WF - GZ$$

$$C = W^2 + G^2 - U^2$$

$$R = \frac{(\sqrt{B^2 + AC}) - B}{A}$$

$$R_1 = \frac{(\sqrt{B^2 + AC}) + B}{A}$$

$$X = G + ZR$$

$$X_1 = G - ZR_1$$

$$Y = W + FR$$

$$Y_1 = W - FR_1$$

New developments in

Structural Adhesives

This symposium covers the development of high-temperature structural adhesives in tape form, and adhesives for metal-to-metal bonding of aluminum and stainless steel at temperatures to 1000 F. Abstracts were taken from recent WADC reports.

Tape Adhesives

for aluminum-joint bonding

By J. M. BLACK and R. F. BLOMQUIST
Forest Products Laboratory
Forest Service
U. S. Dept. of Agriculture
Washington, D. C.

This abstract summarizes results of improving heat-resisting properties of a phenol-epoxy resin adhesive in supported tape form for bonding aluminum sandwich structures. The adhesive possesses high heat-resistance for varying periods of time at temperatures to 600 F.

FOR bonding aluminum, a tape adhesive has certain advantages over an adhesive applied to the metal as a liquid in a solvent. Use of a tape adhesive for bonding sandwich constructions is considered more desirable than a liquid adhesive because flow and filleting properties of the adhesive are critical. It is believed these properties can be controlled more readily in a tape adhesive by use of fillers in the tape and adequate precure of adhesive in tape form. A tape form of adhesive shows loss in resistance to aging in aluminum-lap specimens at elevated temperatures when a glass mat material with starch binder is used as supporting medium.

These conclusions are based on tests of 0.5-in. overlap joints made of 0.064-in. thick 2024-T3 clad aluminum alloy. Surfaces were chemically cleaned and air dried. Tape modifications were made by impregnating a fiber mat with liquid adhesive by a solvent-casting method on Teflon film. The film was cured at 320 F for 1 hr at a pressure of 50 psi.

Although heat resistance of tape modifications is improved with certain binders, a considerably greater increase in resistance to heat aging is obtained with glass-cloth carriers. Also, thermal resistance of adhesive appears to be reduced by glass-cloth carriers. With increased aging periods, joint strengths at room temperature after heat aging are lower than those for bonds made with liquid adhesive. There is a close association between decrease in joint strength and increase in charring or discoloration of adhesive in joints at room temperature, and at 500 F with increased aging time.

Metal ions, particularly zinc, deposited on lap joints before bonding, improve resistance of the bond to aging at elevated temperatures. In some cases, glass fibers are embrittled by this treatment, and cloth cannot be handled for subsequent impregnation as a supporting medium for adhesive.

Adhesive tapes supported by asbestos show a generally lower thermal resistance than adhesives prepared on glass cloth. Asbestos material is never completely impregnated by liquid adhesive even with methods which are satisfactory for glass cloths. The most promising material is a felt which retains a strength of 900 psi at room temperature after aging 100 hr at 500 F.

Fillers not only prevent formation of channels during cure but also are helpful during drying or precure of the tape by forming nuclei for rapid release of solvent. Addition of filler can also be of

value in controlling subsequent flow of resin components of adhesive during bonding. Adhesive formulations with zinc powder and barium sulfate show promising thermal resistance with slight improvement of joint strength after aging.

Various tape modifications and bonding conditions have been tried to produce the most heat-resistant bond possible between core and facings of sandwich constructions so that failing stresses are transferred to the core at all temperatures.

Following are the results of sandwich bonding study:

1. Domestic China Clay, based on resin solids of adhesives, contributes to a flexure strength of bonds at elevated temperatures.
2. Postcuring at 320 F for 16 hr increases bond strength at elevated temperatures.
3. Adhesion of adhesive to aluminum faces is more critical in flexure than in lap-shear tests.
4. Adhesion to aluminum is improved by heating the surfaces at 320 F for 30 min after standard treatment in sulfuric-acid sodium-dichromate solution.
5. Releasing volatiles in early stages of the cure improves bond strength.

From "Development of Metal-Bonding Adhesive With Improved Heat Resistance," WADC Technical Report 56-650, *PB* 121856. *Distributed by Office of Technical Services, U. S. Dept. of Commerce, Washington* 25, *D. C.*

Ceramic Structural Adhesives

By H. G. LEFORT, R. M. SPRIGGS, and D. G. BENNETT
University of Illinois
Urbana, Ill.

Future adhesives will exhibit thermal expansions approaching those of the metals bonded, and viscosities such that the adhesives will be considered rigid for long periods of time at 1000 F

CERAMIC structural adhesives for high-temperature use have been developed recently for bonding Types 301, 302, and 17-7 PH stainless steels. Ceramic adhesives have been found which yield 1200 psi shear strength at room temperature, 1100 psi at 600 F, 1500 psi at 800 F, 2300 psi at 900 F, and 800 psi at 1000 F. However, no single adhesive exhibits all these strengths.

Stainless steel screens as carriers generally increase the average shear strength of bonded parts. As mesh size of the screen becomes finer, shear strength increases until a mesh size of 120 develops the most uniform shear strength values over a given temperature range. Copper screens of 60 mesh yield a high of 1180 psi at 800 F.

Techniques of material and adhesive preparation and fabrication such as knurling, mechanical scouring, chemical pickling and etching, and use of foils as carriers do not improve shear strength significantly. Thickness of adhesive joints affects shear strength but not according to any particular trend. In general, thinner ceramic joints give increased shear strength.

Results of using porcelain enamel adhesives on iron show that the closer the thermal expansion of the adhesive to that of the iron, the higher the resulting shear strength at all temperatures. One ceramic adhesive used with Type 302 stainless steel yields room temperature stress rupture results of 700 psi for approximately 180 hr. Honeycomb sandwiches of Armco 17-7 PH stainless steel with skin thicknesses of 0.016 to 0.047 in. can be bonded successfully with ceramic adhesives. The adhesive offers oxidation protection to core material especially at elevated temperatures.

Future adhesives will exhibit thermal expansions approaching those of metals bonded, maturing temperatures compatible with temperatures of heat treatment of 17-7 PH and other precipitation-hardened stainless steels, and viscosities such that adhesives will melt and flow at extreme temperatures yet will be considered rigid for long periods of time at 1000 F. Investigations of solid solution ceramic-metal materials in which a ceramic oxide matrix is used with a metal, and high-temperature adhesives that possess nonbrittle, good shear strength properties are slated for the near future.

Development of adhesive-joint thicknesses of less than 1 mil, and dispersions of metal particles in adhesives for increased shear strength properties are probable.

From "Research on Elevated Temperature Resistant Ceramic Structural Adhesives," WADC Technical Report 55-491, *Part* 2, *PB* 121941. *Distributed by Office of Technical Services, U. S. Dept. of Commerce, Washington* 25, *D. C.*

New High-Temperature Structural Adhesive

Development of this inorganic polymer adhesive for bonding stainless steel will result in increased flexural strength

AN inorganic material which has adhesive properties and is stable to 800 F is the result of recent research in high-temperature, metal-to-metal structural adhesives.

Following are conclusions reached as a result of investigations of the adhesive on stainless steel joints:

1. Room temperature shear strength of the adhesive is 285 psi.
2. Adhesion is the result of chemical interaction between reaction product and steel.

3. Titanium-dioxide priming of the steel increases bond strength from 65 to 120 psi.
4. Some primers have a negative effect on bond strength.
5. Pressure during cure results in greater bond strength.
6. Fillers in adhesive reduce joint shear strength, cause considerable shrinkage of the mixture during cure, and brittleness after cure.
7. Variation in curing time may increase or decrease adhesive strength.
8. Treatment with solvent increases shear strength of the adhesive.
9. Reduced shear strength occurs as a result of unclean joints.

Future development of this particular adhesive should result in increased heat stability properties and flexural strength. The adhesive will probably be changed from a solid to a more readily applied form.

From "Research on Elevated Temperature Resistant Inorganic Polymer Structural Adhesives," WADC Technical Report 55-271, Part 2, PB 121908, by H. H. Levine, Quantum Inc. Distributed by Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

DC Braking of AC Motors

By J. C. MAROUS
Application Engineer
Westinghouse Electric Corp.
Charlotte, N. C.

DIRECT-CURRENT braking of ac motors has been the answer to braking problems in many industries. Braking with direct current offers the following advantages:

1. Quick smooth stops at all times.
2. Constant degree of braking at all times with no periodic adjustments required.
3. Braking effect easily adjusted over a wide range.
4. Maintenance cost and downtime greatly reduced over mechanical brakes. No moving parts to wear or replace.
5. Reduces power consumption.
6. Saves valuable floor space.
7. Eliminates motor reversing.
8. Reduces heating in the motor as compared to plugging the motor to a stop.
9. Eliminates disturbing solenoid hum.
10. Requires no special double extended shaft motor.

Principle of Operation: Direct-current braking is a special form of regenerative braking obtained by applying direct current to two terminals of a three-phase motor. This sets up stationary magnetic poles around the stator periphery. Braking torque increases as the motor slows down until a peak is reached at approximately 10 to 20 per cent synchronous speed after which braking torque decreases smoothly to zero.

Amount of braking torque can be varied by changing the amount of dc excitation or voltage applied to the terminals of the motor. Peak torque is of particular importance due to stresses set up in the motor. It is advisable to limit peak torque to 700 per cent of full-load torque of the motor.

Motor Losses With DC Braking: Losses which occur in a motor with dc braking are of interest when comparing them with plugging a motor to a stop.

Losses with dc braking are equal to the stator copper loss plus rotor loss. Total loss during a dc braking stop is approximately equal to total loss in the motor for normal acceleration. Losses when plugging to a stop are approximately three times accelerating losses. Therefore, with dc braking, there is less heating. This is a very important factor affecting life of the motor on severe duty cycles requiring frequent starting and stopping.

From a paper entitled "D-C Braking of A-C Motors in the Textile Industry," presented at the ASME Fall Meeting, Hartford, Conn., September, 1957.

Numerically Controlled Machine Tools

By M. V. HAYES
Jones & Lamson Machine Co.
Springfield, Vt.

NUMERICALLY-controlled machine tools show up to particular advantage in three areas:

1. They are useful in making prototype products, dies, and fixtures which have not been made before and for which no tooling exists. Also, they are useful in going from engineering drawings or specifications to metal for the first time because tape is prepared directly from the drawing. A numerical control tape can be a direct bridge from the designer's concept to the material part.
2. They are useful in producing objects in small quantities where expensive tooling and jigs are not justified. Tape replaces tooling and jigs and is cheaper.
3. They are useful in producing objects which are manufactured in small lots at one time.

They do not show up to best ad-

vantage in mass-producing parts directly. For mass production, it is desirable to use special-purpose multiple-tool set ups which do not lend themselves to numerical control. However, one stage removed from actual mass production, numerical control shows great promise in producing dies, jigs, and tooling for mass production processes.

Machine Types: End-point machines make straight or circular cuts or movements which are specified by end points only. These machines require comparatively few commands, little tape, and slow readers. Contouring machines cut arbitrary curves which must be specified at frequent intervals along the curve if any accuracy is required. These machines require long tapes, fast readers, and are more expensive and elaborate. Other types include semiautomatic and fully automatic machines.

Programming Problems: For use with end-point machines, conventional dimensions must be converted to co-ordinates, all referenced to the proper zero co-ordinate. In this case, programming is relatively simple. Programming a contouring machine is a much more elaborate process. The chief problem here is the computation required for sufficient points on a curve so that the machine will cut within tolerances.

Drafting Room Problems: Most end-point machines use co-ordinate systems where end-point B, for example, is given as x inches from some reference point rather than as y inches from previous end-point A. Engineering drawings are conventionally dimensioned end-point to end-point. While it takes only addition and subtraction to convert from one system to the other, nevertheless, if numerically controlled machines become generally used it may be desirable to change the conventional dimensioning system to a co-ordinate system for efficient programming.

More basically, the advent of both computing machines and numerically controlled machine tools raises the question whether drawings (other than sketches for mental clarification) are needed at all.

From a paper entitled "The Use of Numerically Controlled Machine Tools," presented at the ASME Fall Meeting in Hartford, Conn., September, 1957.

Summary of enclosure types of

Integral Horsepower Motors

By J. B. WREN
Motor Dept.
Westinghouse Electric Corp.
Buffalo, N. Y.

TYPES of enclosure design of a motor are determined by the amount of protection provided by frame and end brackets. An open machine has ventilating openings which permit passage of external cooling air over and around windings. Applications include operation in areas where there is considerable airborne contamination. The motor has double-end ventilation. Rotor and cooling fins are specially designed to pull contaminated air through passages without clogging. Windings are of special design built up with a plastic filler. These motors are self-cleaning.

The screened motor is essentially one having a standard drip-proof enclosure modified by addition of screens over air intake openings to prevent entry of dirt particles. Periodic cleaning of screens is required.

The twister motor is a vertical motor of special short length and smaller than normal frame diameter designed especially for operating in cramped quarters. It is not used where contamination is a problem.

All of the following machines are designed for use in areas where airborne contamination is a problem. A totally enclosed machine prevents free exchange of air between the inside and outside of the case but is not airtight. The totally enclosed nonventilated motor is cooled entirely by radiating ability of its outer surface. The totally-enclosed fan-cooled motor is equipped for exterior cooling by a fan integral with the machine but external to enclosing parts. The motor must operate without becoming clogged.

Other special enclosures defined by NEMA include totally enclosed pipe-ventilated enclosures, totally enclosed water-cooled enclosures, and totally enclosed water-air cooled enclosures. In some installations where ambient air is not suitable for cooling, air for cooling must be piped into the motor. Also, heat from motor losses may be objectionable to operations in the immediate area and must be piped away or removed by water-cooled heat exchangers. Hence, the NEMA designations.

In general, if motors are open, contaminated air must either pass through the motor without clogging passages, or must be screened before entering. If motors are enclosed, fan-cooled types must allow particles to pass through. Nonventilated motors should not be adversely affected by a buildup of dirt which does not prevent heat radiation from the case surface.

From a paper entitled "Modern Textile Motors," presented at the ASME Fall Meeting in Hartford, Conn., September, 1957.

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

High Temperature Alloy

Recommended for use at high stresses up to 1500° F, Multimet alloy can also be used at moderate stresses up to 2000° F. Full data on properties of this material in wrought and cast forms are cited in Bulletin F-30036. Successful aircraft and industrial uses are covered. 24 pages. Haynes Stellite Co.

Circle 501 on page 19

Switches & Relays

Stepping switches, relays, and key switches for practically every control need are briefly described in Circular No. 1843-E. Similar to telephone equipment, units are available in wide range of capacities and contact arrangements. 4 pages. Automatic Electric Sales Corp.

Circle 502 on page 19

Research Services

"Product Research and Development" is title of illustrated booklet describing services offered in this field. Brochure outlines services available in areas of product planning and design, materials, production, and processes. 20 pages. Franklin Institute Laboratories.

Circle 503 on page 19

Air & Vacuum Pumps

Catalog No. 757 describes line of rotary positive air and vacuum pumps and their accessories. Integral, direct coupled, and belt driven models are covered, along with dimensions, capacities, and performance curves. 16 pages. Leiman Bros., Inc.

Circle 504 on page 19

Clamps & Fasteners

Clamps and fasteners for closing containers and access panels are subject of illustrated catalog. Data are given on hook, loop, hinge, spring-loaded, and special duty clamps. 16 pages. Bassick Co.

Circle 505 on page 19

Seals

"Designed for Sealing" is title of comprehensive technical guide to fastener, fitting, closure, flange and orifice, and electrical and electrochemical seals; O-rings; and other sealing products available from this firm which specializes in static sealing design and manufacture. 18 pages. Franklin C. Wolfe Co.

Circle 506 on page 19

Fluid Filter

Features of a redesigned line of filters available in carbon or stainless steel types with Poro-Stone, Poro-Carbon, or Poro-Screen elements for use at pressures to 100 psi are covered in Bulletin 615. They are suited for handling corrosive gases and liquids. 2 pages. R. P. Adams Co.

Circle 507 on page 19

Welding Rod

Physical properties as-welded, analysis, tensile strength, elongation, average Rockwell hardness, and typical uses of gas welding rods, bar electrodes, automatic welding wire, and metal spray wire are listed in Comparison Chart DH-1218-K. Virtually all competitive makes are included. 4 pages. American Chain & Cable Co., Page Steel & Wire Div.

Circle 508 on page 19

Potentiometers

Pick-off and sector potentiometers for aircraft and missile control systems are specified in Bulletin No. 415. Units will operate in damping fluids, and in temperatures in excess of 150° C. 2 pages. Norden-Ketay Corp.

Circle 509 on page 19

Electronic Components

Line service test equipment, speakers, styluses and cartridges, TV receiver parts, service parts for radios and phonographs, and batteries are some of the products listed in bulletin entitled "RCA Electronics Components." 22 pages. Radio Corp. of America, RCA Components Div.

Circle 510 on page 19

Circulating Pumps

Vertical, immersion type, circulating pumps for use in process equipment and systems are described in Bulletin 4310. Capacities range from 10 to 500 gpm. 4 pages. Deming Co.

Circle 511 on page 19

Airborne Components

Transducers, accelerometers, gyros, temperature probes, and vane transducers are some of the items described in illustrated catalog entitled, "Airborne Components." 56 pages. G. M. Giannini & Co.

Circle 512 on page 19

Belting

How Electro-Tensile Control is combined with the Rotocure process to provide balanced belt construction is explained in Form No. 1202. This feature is available in complete line of conveyor, transmission, and elevator belts. 4 pages. Boston Woven Hose & Rubber Co.

Circle 513 on page 19

Power Transistor

Complete data and test circuit diagrams covering the military specification for Clevite 2N297 power transistors are contained in Bulletin No. B-214. This hermetically sealed PNP alloy junction germanium transistor is designed for high-current switching and audio frequency power amplifier applications. 4 pages. Clevite Corp., Clevite Transistor Products Div.

Circle 514 on page 19

Blind Fasteners

"Blind Bolts for High Strength Blind Fastener Applications" is title of bulletin that discusses advantages of blind bolts and blind nuts in structural and repair applications. Design considerations are covered. 8 pages. Hi-Shear Rivet Tool Co.

Circle 515 on page 19

Custom-Molded Teflon

Details of a patented process for custom-molding parts of Teflon in thin sections and shapes are presented in illustrated bulletin. Typical parts such as cup, ball, or shaft seals; washers; gaskets; and diaphragms are shown. 4 pages. Sparta Mfg. Co.

Circle 516 on page 19

Molecular Sieves

Use of Molecular Sieves as a drying agent for gases is covered in Bulletin F-1026. Tables and charts provide engineering data for preliminary designs of low dewpoint drying systems. 20 pages. Linde Co.

Circle 517 on page 19

Oscillographic Recorders

One to eight-channel oscillographic recording systems in the 150 series are described in "Short Form Catalog." Specifications are included on basic assemblies as well as system components. 4 pages. Sanborn Co., Industrial Div.

Circle 518 on page 19

Acceleration Generator

Bulletin No. S-120 gives details of the Model AAc-2 angular acceleration generator that permits a new series of dynamic acceleration tests in addition to its function in the calibration of accelerometers. 2 pages. Statham Development Corp.

Circle 519 on page 19

Indicator Lights

Check chart facilitates the selection and application of lamp holders and indicating lights for military needs which conform to MIL-L-3661 specification. 1 page. Drake Mfg. Co.

Circle 520 on page 19

Magnetic Tape

Six types of Scotch brand magnetic tapes for instrumentation recording are subject of illustrated booklet. Factors which adapt tape for use in telemetering and airborne recording,

machine tool control systems, computers, geophysical recording, and other instrumentation applications are detailed. 8 pages. Minnesota Mining & Mfg. Co.

Circle 521 on page 19

Plastic Molding Compounds

Plaskon urea, melamine, and alkyd molding compounds, as well as nylon molding and extrusion compounds are discussed in Bulletin P-95. Properties which adapt each material for specific applications are covered briefly. 4 pages. Allied Chemical & Dye Corp., Barrett Div.

Circle 522 on page 19

Engine Hour Meters

Hobbs engine hour meters are accurate timing instruments which tell at a glance the actual hours and minutes of engine or machine operation. Alternating and direct current types are available for use on mobile equipment as well as on machine tools, power conveyors, lighting systems, packaging machines, and various other equipment. 12 pages. John W. Hobbs Corp.

Circle 523 on page 19

Transmission Belts

Transmission belts for spindle speeds up to 100,000 rpm are subject of descriptive bulletin which includes technical details. Graphs show results of competitive tests on belt life and elongation. 6 pages. Russell Mfg. Co.

Circle 524 on page 19

High Torque Bolts

Hi-torque bolts described in Bulletin 2-904 are designed for applications to 1500° F in super alloys and titanium. Bolt is made in full range of sizes, in both countersunk and protruding head configurations. 4 pages. Hi-Shear Rivet Tool Co.

Circle 525 on page 19

Screw Machine Parts

Thirty special screw machine parts, each made on a single run, are pictured in bulletin entitled "Special Screw Machine Parts." Company facilities for making these parts are briefly described. 4 pages. Merit Specialties Co.

Circle 526 on page 19

Servomotor-Rate Generator

Data Sheet 872 provides specifications, characteristics, drawing and schematic on Model 11 MG 460/460 Beckman servomotor-rate generator. The Size 11, 115-v, 400-cycle unit weighs 7.1 oz. 2 pages. Helipot Corp.

Circle 527 on page 19

Polyethylene

Typical physical properties of Super-Dylan polyethylene are tabulated in Bulletin C-7-135. Information is also given on Dylene regular and expandable polystyrenes. 4 pages. Koppers Co.

Circle 528 on page 19

Pressure Measuring Device

Applications, operating principles, system specifications, and comparative features relative to the Electromanometer are covered in Bulletin 1547 A. This precision pressure-measuring device is intended for lab, field, or automatic process control. 4 pages. Consolidated Electrodynamics Corp.

Circle 529 on page 19

Socket Screw Products

Revised basic Unbrako catalog reviews complete line of standard socket screw products, pressure plugs, and dowel pins. Socket-head cap and set screws covered range in size from No. 0 microsize set screw 1/16 in. long to the giant-size cap screw 3 in. in diameter and 12 in. long. Stripper bolts, flat heads and button heads are also covered. 32 pages. Standard Pressed Steel Co.

Circle 530 on page 19

Refrigeration Equipment

Company's facilities, engineering capabilities and diversification in serving the refrigeration industry are pointed up in Bulletin 5805. Variety of copper and aluminum tube and spun end tubular products are shown. 12 pages. Calumet & Hecla, Inc., Wolverine Tube Div.

Circle 531 on page 19

Explosive Ordnance Items

Condensed Data Bulletin CD-1-57 covers such explosive ordnance items as electric primers, electric squibs, igniters, explosive bolts, Cad cartridges, gas generators, power packs, ejectors, and high pressure terminals. It lists applications in rocket, missile, aircraft, and industrial fields. 4 pages. McCormick Selph Associates.

Circle 532 on page 19

Self-Locking Threaded Parts

How the locking-sealing, protruding nylon pellet can be applied to any threaded part regardless of size, shape, or function is explained in Manual 571. Describing Nylok-Detroit threaded parts, manual also includes basic engineering recommendations. 4 pages. Nylok-Detroit Corp.

Circle 533 on page 19

Enginering Services

File size folder describes engineering services offered producers of industrial goods, consumer goods and ordnance items. Services envelop product engineering, design and development, production engineering, graphic arts, and plant services. 6 pages. Production Services Corp.

Circle 534 on page 19

Gears

A 50th Anniversary pamphlet describes company's facilities and industrial background. It also illustrates and specifies the capacities of spur, internal, spiral and helical, bevel, and miter gears; silent and roller chain sprockets; worms and gear worms; and racks. Braun Gear Co.

Circle 535 on page 19

Electro-Chemical Switches

Specifications and engineering data on Series 300, 350, 400, and 450 Squib electro-chemical switches are given in data sheet. Switches are used in missile switching, aircraft emergency systems and telemetering. Contacts will carry 25 amp indefinitely, 200 amp for 100 milliseconds. 4 pages. Atlas Powder Co.

Circle 536 on page 19

Timers & Program Switches

Military-specification time delay relays and sequence program switches are described in Engineering Data Sheet No. 5. Diagrams of a typical repeat cycle with up to six load circuits and a typical reset cycle with up to five load circuits are included. 4 pages. Automatic Timing & Controls, Inc.

Circle 537 on page 19

Belting

Catalog and engineering handbook provides technical data and formulas relative to industrial conveyor and elevator belting. Featured brand recommendation chart simplifies choosing the right belting for each job. Tips for assuring longest belt service are provided. Imperial Belting Co.

Circle 538 on page 19

Rotary Stepping Switches

Specifications and mounting data are given in Circular 1698-G on Series OCS relay and Types 44 and 45 rotary stepping switches used for self-interrupted or impulse-controlled operations. Units feature split second response and stamina for millions of operations. 8 pages. Automatic Electric Sales Corp.

Circle 539 on page 19

Wire, Rod, & Strip

Technically, Price Schedule No. 12 is a handbook providing data on chemical, physical and mechanical properties on Techalloy alloywire, rod, and strip. For purchasers, it is an easy-to-use price schedule with extras listed on one page to save figuring time and eliminate errors. 35 pages. Techalloy Co.

Circle 540 on page 19

Glass-to-Metal Connectors

Selecting and specifying sealed glass-to-metal AN connectors is simplified with Catalog 657C which shows wide range of shell sizes and insert configurations for aircraft, communications, electronic controls, and instrument applications. Units withstand voltage breakdowns over 1000 v and pressures to 7000 psi. 16 pages. Hermetic Seal Corp.

Circle 541 on page 19

Selenium Rectifier

Miniature double-diode Vac-u-sel selenium rectifier for television horizontal-phase-detector diode is described in illustrated Bulletin GEA-6538B. Applications, models, specifications, and ratings are covered. 2 pages. General Electric Co.

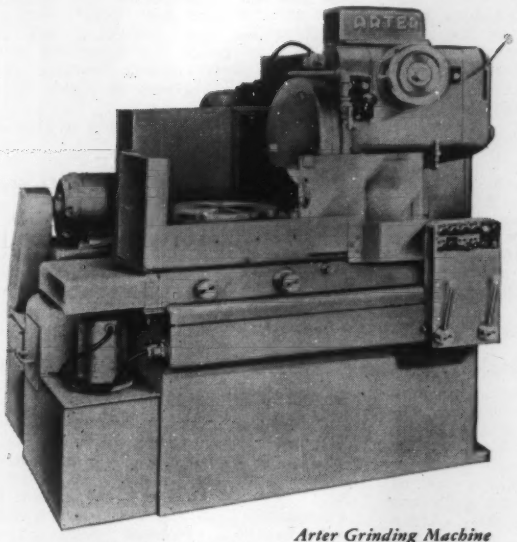
Circle 542 on page 19

High Strength Ceramics

Mechanical rotary seal parts of high strength alumina ceramic are described in illustrated Catalog 1055. Physical properties and design tips for the ceramic materials are presented. Among other parts shown are

WELDED STEEL MACHINE BASE

costs less . . . is more rigid



Arter Grinding Machine Company has been using welded bases for ten years. This is a rotary surface grinder whose base and column were designed as a weldment to obtain rigidity with minimum weight.

ARTER GRINDING MACHINE COMPANY finds Welded Steel the economical answer to vibration in machine tools

The superior properties of steel have been employed by the Arter Grinding Machine Company of Worcester, Massachusetts, to achieve a more rigid, vibration-free machine at less cost.

The Arter engineering department emphasizes the advantages of weldments in the following statement:

"Experience gained makes it possible to design a welded base of ample strength and rigidity to absorb vibrations and prevent the slightest distortion in lifting or moving a machine onto its foundation. Should a weak spot show up, it is a comparatively simple matter to weld in reinforcing gussets. Such a condition in a casting, on the other hand, becomes a more difficult matter to correct."

Because steel is more rigid and stronger than gray iron, less material is required to duplicate the strength of a casting. This economy of material combined with versatility—the ability to reinforce where necessary—provides a stronger, more rigid, vibration-free machine at less cost.

DESIGN HELPS FOR DESIGN ENGINEERS

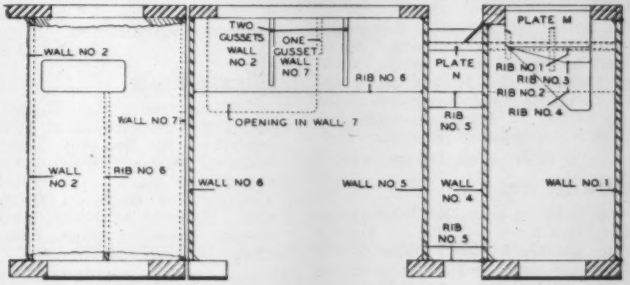
"Procedure Handbook of Arc Welding Design and Practice" 11th Edition. 1300 pages with latest procedures. Fully illustrated. Includes 240 page section giving latest developments in machine design. Price $3.00 postpaid in U.S.A. $3.50 elsewhere.

Seminars in use of Welded Steel in Machine Design for design engineers. Conducted regularly at Lincoln plant in Cleveland.

"Machine Design Sheets", with helpful ideas in applying welded steel, are free.

Write us for details.

Drawing of cross section of part of the base of the above machine.



LINCOLN

THE LINCOLN ELECTRIC COMPANY

DEPT. 1126 • CLEVELAND 17, OHIO

The World's Largest Manufacturer of Arc Welding Equipment

When steel is 2½ times more rigid

Has 3 times the strength of iron

Yet costs ⅓ as much per pound

WHY AREN'T YOUR MACHINES DESIGNED FOR WELDED STEEL?

pump plungers, chokes and nozzles, coil forms, and insulators. 12 pages. Coors Porcelain Co.

Circle 543 on page 19

Teflon Tubing

Chemical inertness, flexibility, and toughness, even at the temperature of liquid oxygen, are features of Teflon tubing, stocked in 1/16 to 1-in. ID sizes, and described in Bulletins 4 and 5. Applications and properties are covered. 2 pages each. Pennsylvania Fluorocarbon Co.

Circle 544 on page 19

Flexible Shafts

Bronze and ball bearing equipped flexible shafts for power transmission, subject of illustrated Bulletin 250, are offered in seven sizes from ¼ to 1¼ in. diameter and in four lengths. Specifications, ordering information, and scale drawings are included for each model. 12 pages. B. W. Elliott Mfg. Co.

Circle 545 on page 19

Roll Design

How correct design can eliminate serious vibrations in rotating rolls by avoiding their critical speed is discussed in Industrial Roll Report 13. Mathematical formula for determining the first critical speed of a roll is included. 2 pages. Rodney Hunt Machine Co.

Circle 546 on page 19

Plug-In Amplifiers

Solving difficult amplifier problems with transistorized units is detailed in case history brochure. Compact 20-w public address system amplifier and a high-gain audio amplifier that is interchangeable with a vacuum tube unit are covered. 4 pages. Universal Transistor Products Corp.

Circle 547 on page 19

Spherical Bearings

COM Series of spherical bearings, comprised of low carbon steel outer race and hardened steel ball, is subject of Bulletin 257. Eleven sizes are offered in static load capacities from 3250 to 54,700 lb. Stephens-Adamson Mfg. Co., Sealmaster Bearing Div.

Circle 548 on page 19

Stainless Filters

Characteristics, applications data, and specifications on line of porous sintered stainless steel filters are found in Catalog 54-101. A selector chart and filtration data tables are included. Filters are designed for use at 1000° F or higher. 12 pages. Cuno Engineering Corp.

Circle 549 on page 19

Electric Power Supplies

Twenty new dc to dc, dc to ac, and dc to multiple ac and dc output transistorized power supplies are described in Catalog 58P. Capacities range to 500 va. 8 pages. Power Sources, Inc.

Circle 550 on page 19

V-Belts

Cross-reference information on every variable speed V-belt for every type or make of unit is given in Catalog and Reference Handbook. Interchange listings, including drive data and manufacturer's part number listings, are given. 24 pages. Dayton Rubber Co., Industrial Div.

Circle 551 on page 19

Titanium

"Titanium Production and Use" is title of Booklet ADV-903 which explains and illustrates titanium production and processing at Republic Steel. Mechanical properties and typical uses of the metal are described. Republic Steel Corp.

Circle 552 on page 19

Hydraulic Hose & Fittings

Rubber covered single wire braid hose and reusable Hoze-lok fittings which do not require the hose cover to be skived off are described in illustrated Catalog 4434. Hose sizes range from 3/16 to 1 13/16 in. ID. Fittings covered have four different connection ends. 4 pages. Parker-Hannifin Corp.

Circle 553 on page 19

Panel Lights & Switches

Line of tiny indicating lights and switches is described in three illustrated Handbook Specification Sheets. Pan-i-Lite low voltage indicating switch with ⅝-in. diameter can be seen at 180 degrees and at long distances. Pushbutton bulb-lens assembly in an integral unit. Alden Products Co.

Circle 554 on page 19

Seamless Tubing

Those involved with design, fabrication, or production of equipment involving use of hollow cylindrical parts will have use for Bulletin TB-340A, "A Guide to the Choice of Seamless Mechanical Tubing." Tolerances, costs, machinability, surface finishes, and other details are given. 8 pages. Babcock & Wilcox Co., Tubular Products Div.

Circle 555 on page 19

Silicone Resin

Silicone resin R-7141 for bonding low pressure structural laminates is described in Bulletin 7-408. Developed for vacuum molding of complex structural parts, it provides high strength at elevated temperatures, good thermal stability, and low dielectric losses. 1 page. Dow Corning Corp.

Circle 556 on page 19

Computing Equipment

Among 17 instruments described in illustrated short form Catalog C704 are nuclear scalers, recorders, and readouts, preset Eput meters, and Ease 1100 analog computers. Brief specifications are given. 8 pages. Beckman Instruments, Inc., Berkeley Div.

Circle 557 on page 19

Miniature Ball Bearings

Wide variety of types of standard radial ball bearings in sizes from 0.1 to 0.5 in. OD are described and illustrated in 1957 Catalog. Specifications of each type are given. Also covered are series of special ball bearings. Engineering information is also included. 24 pages. Miniature Precision Bearings, Inc.

Circle 558 on page 19

Resistance Wire & Ribbon

Catalog-Manual M-57C details Chromel-C, a 60-16 nickel-chromium-iron resistance alloy used on electrical heating applications not exceeding 1700° F and for "cold" resistor applications not exceeding 800° F. Prices and specs for range of wire diameters and ribbon widths and thicknesses are given. 16 pages. Hoskins Mfg. Co.

Circle 559 on page 19

Insulated Terminals

Wire and cables ranging in size from No. 8 through 4/0 can be fitted with bonded and insulated terminations with process employing Ampli-Bond terminals. Attached with hand or power tools, terminals are color-coded for rapid identification. Full technical and application data are given in Catalog Section AM. 12 pages. AMP Inc.

Circle 560 on page 19

Machine Handles

Details of eleven sizes of solid, hollow, and quick-action machine handles with polished or decorative chrome finishes are given in Bulletin MH. Dimensions are given to aid in application. 4 pages. Rockwood Sprinkler Co., Pressed Metal Products Div.

Circle 561 on page 19

Automatic Equipment Controls

How Micro Switch precision switches assure low cost, reliable controls for automatic operation of plant equipment is explained in Form 84. Applications for process, bulk flow, packaging, motion, counting and weighing, and level control are depicted. 4 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div.

Circle 562 on page 19

Spectrochemical Analysis

Data on a variety of prism and grating spectrographs and related accessories are presented in Bulletin CH403. This is the third in a series of spectrochemical analysis guide books on British-made equipment. 24 pages. Jarrell-Ash Co.

Circle 563 on page 19

Friction Clutch & Brake

Features of the new Type K pneumatic friction clutch and brake unit for outboard and crankshaft mounting on presses are depicted in Bulletin 37-A. It is fast acting, self-aligning, cool running, and self-adjusting. 4 pages. E. W. Bliss Co.

Circle 564 on page 19

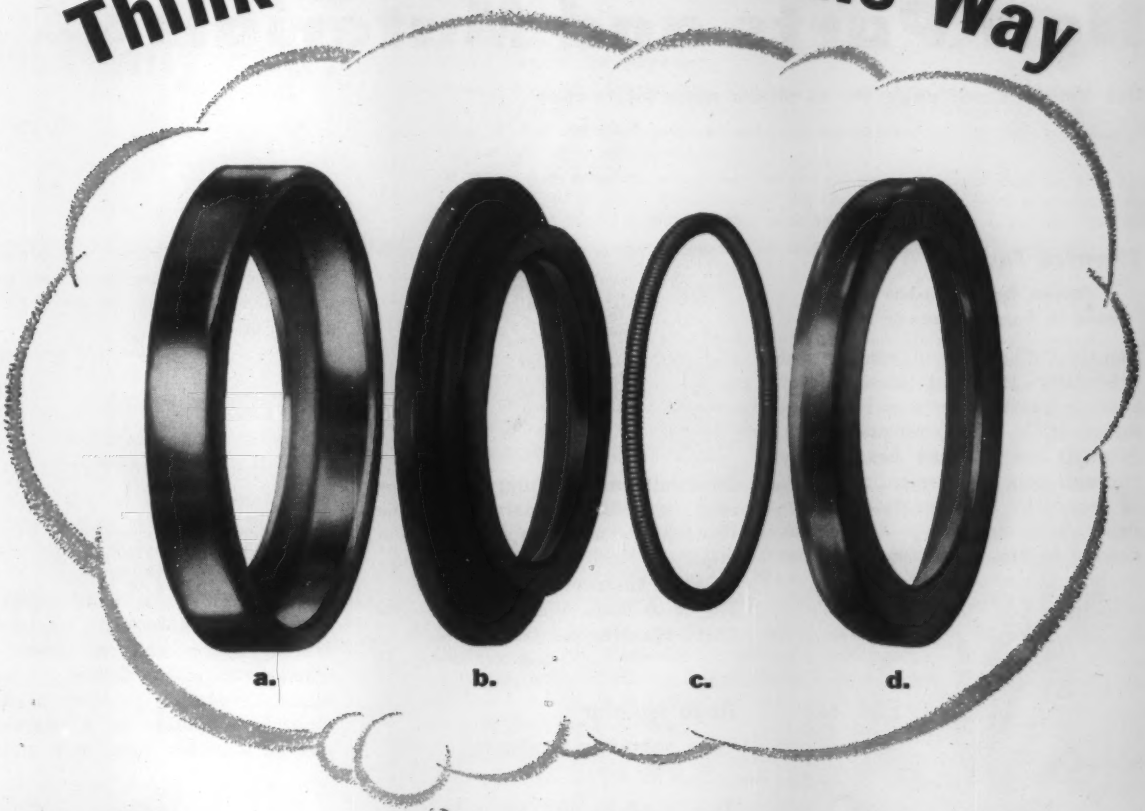
Hose Fittings

Brass hose fittings for low and medium pressure air, spray, steam, suction, welding, and other services are subject of illustrated Bulletin 140. 8 pages. Hose Accessories Co., Le-Hi Div.

Circle 565 on page 19

When you design-in seals

Think of Oil Seals This Way



a. Outer Case

Formed to extreme close tolerance of heavy gauge steel with sufficient structural strength to maintain precision dimension.

b. Sealing Lip

Properly prescribed material either compounded or processed for application conditions of temperature and eccentricities. Precisely molded for correct shaft interference, low torque and positive sealing.

c. Tension Spring

Carefully engineered as to metallurgy, heat treatment and coil diameter to provide uniform compressive force on the sealing element.

d. Inner Case

Strengthens, protects; sturdy gauge steel formed to close tolerances.

4227

A good oil seal is a carefully engineered, precision manufactured assembly of carefully engineered, precision manufactured components. Each part must be exactly right *for the given application* or the seal will not function properly.

You avoid dangers of costly retooling, remanufacture or premature replacement when seals are correctly specified during your product's design stage. Each sealing application is different; many designers use National's field engineering service to be sure correct—and latest—oil seals are used.

Why "do it yourself?" Call the National Seal field engineer now. His service involves no obligation.

NATIONAL SEAL
DIVISION, Federal-Mogul-Bower Bearings, Inc.
GENERAL OFFICES: Redwood City, California
PLANTS: Van Wert, Ohio, Redwood City and Downey, California

CATALOGS (S) IN SWEET'S

36th year

CHICAGO, ILL. . . *Room 462, McCormick Building, HArrison 7-5163*
CLEVELAND, OHIO . *210 Heights Rockefeller Bldg., YEllowstone 2-2720*
DETROIT, MICH. . . . . *13836 Puritan Avenue, VErmont 6-1909*
DOWNEY (Los Angeles County), CALIF. . . *11634 Patton Road, TOpaz 2-8163*
INDIANAPOLIS, INDIANA . *2802 North Delaware Street, WAlnut 3-1535*
MILWAUKEE, WIS. . . *647 West Virginia Street, BRoadway 1-3234*
NEWARK, N. J. . . . . *1180 Raymond Blvd., MItchell 2-7586*

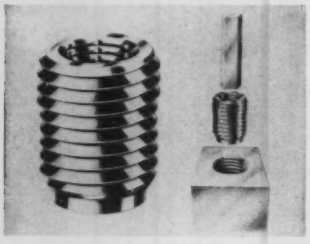
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Threaded Fastener

is driven by a hex-bar used in hand or power tool

Inserto U-Tap is an internally and externally threaded steel insert that locks itself into parent material at specified torque levels. Internal threads are hexagonally through-broached the entire length of insert to accommodate a hex-drive bar, the only implement needed to drive the insert. It can



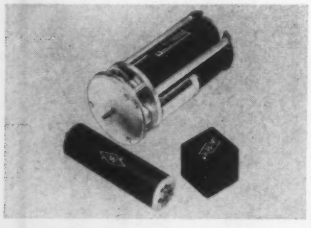
be used in any hand or power tool. Fastener has standard form internal and external threads, and is installed into a standard Class 3 tapped hole. Insert is case-hardened to protect internal threads permanently against wear or damage. It is available in several sizes. **Rosan Inc.**, 2901 West Coast Highway, Newport Beach, Calif.

Circle 566 on page 19

Servo Repeater System

packaged unit has miniaturized components

Model W1801 servo repeater system (top) includes a transistorized servo amplifier, motor, synchro, power supply, and gear train, in a housing 2 in. in diam by 4 in. long. Power-supply requirements are 10 w, 400 cps, at either 115 or 26 v. Transistorized servo amplifier is available separately, in a 13/16-in. diam x 2¾-in. long case



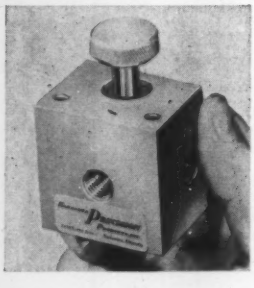
for minimum mounting surface, or in a 1-in. cube for minimum volume (bottom). All components meet applicable military specifications. **Waldorf Instrument Co.**, Div., F. C. Huyck & Sons, Wolf Hill Rd., Dix Hills, Huntington Station, N. Y.

Circle 567 on page 19

Gage Isolator

for operating pressures to 5000 psi

This gage isolator protects fluid-pressure gages from excessive surge pressures. Since gage is isolated from the system except when readings are taken, gage accuracy and reliability are maintained. Unit is a spring-loaded device which is normally closed. Depressing a pushbutton opens gage line to permit a reading. Releasing pushbutton closes line, isolating gage from rest of circuit. Isolator, designed for operating pressures to 5000 psi, can be used with any hydraulic oil and many other fluids. It is equipped with ¼-in. NPFT ports



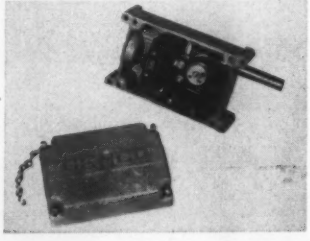
and holes for panel or bracket mounting. **Sarasota Precision Products Inc.**, 1314 N. Lime Ave., Sarasota, Fla.

Circle 568 on page 19

Rotary Limit Switch

has three microswitches and three adjustable cams

This limit switch is available in ratios of 5:1, 10:1, and 20:1. It has three microswitches and three independently adjustable cams. Switch is used for machine tools, automation equipment, motor-operated doors and windows, or wherever a motor drives a mechanism through a rotating motion. Unit is available in a standard molded Fibraloy case, in a water-



tight, cast-aluminum housing, and in an explosionproof enclosure. **Gemco Electric Co.**, 25685 W. Eight Mile Rd., Detroit 40, Mich.

Circle 569 on page 19

Antibacklash Gears

utilize retaining ring to hold floating member in place

Dynaco antibacklash gears are available in Precision Class I and Class II with pitch diameters from 1 to 2 in. They have either solid-end or clamp-type hubs in three bore sizes. Use of a retaining ring to hold floating member in place results in smaller hub diam-

Can specialized business publication advertising actually sell?

By reputation, salesmen are reluctant to credit anything but their own selling efforts for getting names on the dotted line.

Actually, it's quite a different story. The most successful salesmen will tell you two important things about selling. 1. That the selling process is largely a matter of communicating ideas. 2. And that specialized business publication advertising can help importantly to register information with prospects.

Of course each salesman will express this in his own way . . . but they all agree that selling would be far more difficult without the advertising that appears in the industrial, trade and professional publications that serve the specialized markets to which they sell.

Here, for instance, is what a salesman has to say about this kind of advertising:

Fred Snyder, Cleveland District
Worthington Corporation

sells to industry

Says Mr. Snyder:

"We have, of course, sales leads from our business paper advertising that are forwarded to us on a monthly basis. But also the trade advertising has its impact on many who do not at the time request specific information. Worthington is far better known today than it was five years ago, due in no small measure to the aggressiveness of its advertising and sales promotion department.

"Their work makes my job easier. First of all, we have an entree in companies where some Worthington products were not previously as well-known as our original line. We're getting a lot better sales coverage on all products. The Corporation manufactures so many products today that even regular customers may be unfamiliar with some of these products. Through trade advertising and sales promotion we have been able to sell the whole Worthington line.

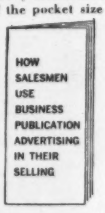
"Getting back to sales leads—they are particularly helpful to our dealers. In Cleveland, W. M. Patterson Supply will undoubtedly receive inquiries from Worthington's advertising. Scott-Tarbell, Inc., Cleveland Oak Belting, or other dealers handling special product lines will pick up leads from our advertising to help them get business.

"I think we've grown eightfold since the war. This year we hit two hundred million. It used to be that twenty-five million was a good year. The advertising and sales promotion department has aggressively been attacking their part of the problem within the last five years. Prior to that the name Worthington was not nearly so well-known and we put much less emphasis on advertising."

Ask your own salesmen what your company's business publication advertising does for them. If their answers are generally favorable you can be sure that your business publication advertising is really helping them sell. If too many answers are negative it could well pay you to review your advertising objectives—and to make sure the publications that carry your advertising are read by the men who must be sold.

How salesmen use their companies' advertising to get more business

Here's a useful and effective package of ideas for the sales manager, advertising manager or agency man who would like to get more horsepower out of his advertising. Send for a free copy of the pocket size booklet entitled, "How Salesmen Use Advertising in Their Selling," which reports the successful methods employed by eleven salesmen who tell how they get more value out of their companies' advertising.



You'll find represented many interesting variations in how they do this. Some are very ingenious; all are effective. You can be sure that more of your salesmen will use your advertising after they read how others get business through these simple methods.

The coupon is for your convenience in sending for your free copy. Then, if you decide you want to provide your salesmen with additional copies, they are available from NBP Headquarters in Washington, at twenty-five cents each. Or, if you choose you can reprint the material yourself and distribute it as widely as you please. But first, send for your free copy.

NATIONAL BUSINESS PUBLICATIONS, INC.
Department 2E
1413 K Street, N. W.
Washington 5, D. C. STerling 3-7533

Please send me a free copy of the NBP booklet "How Salesmen Use Advertising in Their Selling."

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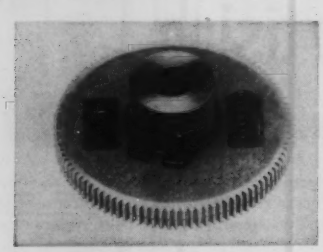
NBP

. . . each of which serves a specialized market in a specific industry, trade or profession.

Circle 444 on page 19



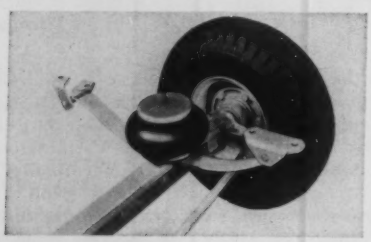
eter with lower polar moment of inertia, and permits disassembly of floating member if desired. **Dynamic Gear Co. Inc.**, 20 Merrick Rd., Amityville, N. Y.

Circle 570 on page 19

Running Gear

is lightweight aluminum unit

Air Flite aluminum running gear has mechanically or hydraulically actuated brakes, and air springs which can be inflated or deflated to meet varying load requirements. Automotive steering assembly provides positive trailing at high and low speeds. For use in aviation and transportation fields, the as-



sembly provides long service life with negligible corrosion. **United Mfg. Co.**, 5250 Dobeckmun Ave., Cleveland 2, Ohio.

Circle 571 on page 19

Textured Vinyl Finish

resists wear and chemical attack

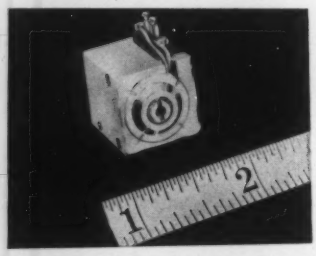
Armorhide, which provides a spray-applied finish resembling grained leather, is available in a wide selection of colors. It resists wear, chemical attack, moisture, perspiration, acids, alkalis, and other corrosives. Finish has rubberlike flexibility and resiliency, and absorbs violent shock without chipping or cracking. Sound absorbent, finish can help to muffle the noise of machine components. It has dielectric strength of 400 to 500 v per mil. Applications include office equipment, business machines, and communications equipment. **Metal & Thermit Corp.**, Rahway, N. J.

Circle 572 on page 19

Linear-Stroke Solenoid

is small, shock-resistant unit

Linear-stroke solenoid is designed for applications in instrumentation and missile control. It is shock-resistant and meets Air Force environmental requirements for installation in fighter planes. Sole-



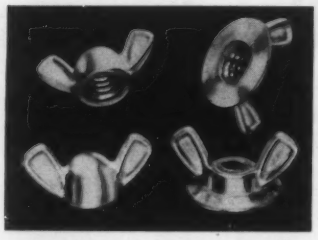
noid is CR steel finished in cadmium plate. Operating on 28 v, the plunger stroke bridges a gap of 0.080 in. at 24 v and exerts minimum pull of 6 oz. Dimensions of the unit are 0.672 x 0.622 x 0.622 in. **J. A. Maurer Inc.**, 37-01 31st St., Long Island City, N. Y.

Circle 573 on page 19

Wing Nuts

in capped and washer-base types

Die-cast in zinc alloy, two styles of wing nuts are rustproof and corrosion-resistant. Capped wing nut, with closed threaded section, provides a decorative means of finishing off bolt ends, seals and protects exposed threads. Blind dome is tapped extra deep to accommodate bolt ends of varying lengths. One-piece, washer-base wing nuts replace a regular wing nut and flat washer. It can be used on assemblies with adjusting slots and oversize holes. Both fasteners are available with 1-in. wing spread in thread sizes from No. 10 to 5/16 in. for the capped unit and No. 8 to 5/16 in. for washer-base wing nut. Fits for both styles are



NC-2 and NF-2. Recessed wings provide a positive grip for nuts. **Gries Reproducer Corp.**, 400 Beechwood Ave., New Rochelle, N. Y.

Circle 574 on page 19

High Nickel Alloy Strip

in thicknesses as low as 0.0005 in.

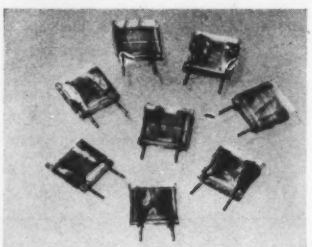
High nickel alloy strip meets miniaturization requirements in aviation, missile, instrumentation, automation, electronics, and electrical industries. It is available in thicknesses as low as 0.0005 in. to tolerances within ± 0.0001 in. High nickel alloys available in this form include temperature-compensation, low-expansion, high-permeability, glass-sealing, and electrical-resistance alloys. **American Silver Co. Inc.**, 36-07 Prince St., Flushing, N. Y.

Circle 575 on page 19

Miniature Capacitors

are fixed-glass types for printed-circuit use

Type WL subminiature fixed-glass capacitors, available at present on a limited production basis, are radial-lead units designed for use on printed-circuit boards. They are also suitable for many other applications. High-temperature soldered leads permit capacitors to be con-



nected directly to circuit board. The two sizes are less than 0.1 in. thick, making them suitable for vertical mounting in small, high-

MECHANICAL ENGINEERS
ELECTRICAL ENGINEERS

Challenging job opportunity on the editorial staff of

MACHINE DESIGN

Here's your chance to break in on a growing field where aggressive creative work is really appreciated. MACHINE DESIGN has a staff opening for an engineer with an interest in both engineering and editorial work. This job provides stimulating contact with many engineering areas plus opportunity to grow and progress as a specialist in a particular branch of design engineering.

Some evidence of design engineering experience is necessary, and an ME or EE degree would be desirable. Writing ability and interest are also required, although a heavy background of editing or writing is not essential.

Salary will depend on experience; progress for the right man can be rapid. Headquarters are in Cleveland with opportunities for travel to attend engineering meetings and expositions.

If you are interested, send full details of your engineering background to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

DURAKOOL Tilt Switches are the Life of your Automatic Controls

This steel-clad Durakool mercury tilt switch has unique construction features that deliver years of trouble-free performance on the most difficult assignments you can find. Operating under sealed-in, pressurized hydrogen gas, it takes 24 hours, fast cycling schedules in stride. 7 sizes, 1 to 65 amperes. Send for Bulletin 525.

MILLIONS OF CYCLES WITHOUT FALTERING

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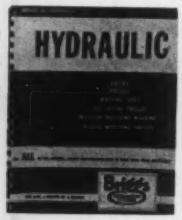
DURAKOOL, INC.
ELKHART, INDIANA, U.S.A.
700 WESTON RD., TORONTO 9, CANADA

Durakool ALL-STEEL MERCURY *Switches*

Circle 446 on page 19

BRIGGS OFFERS YOU, FREE, A 12 PAGE MANUAL ON HYDRAULIC FLUID CIRCUITS AND HYDRAULIC OIL FILTRATION

HERE is a big 8½" x 11", file size, 12 page, fully illustrated booklet. It's brimful of technical data and drawings that every designer and engineer will want to read or keep for ready reference. Write for your copy. No obligation.



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THE BRIGGS FILTRATION COMPANY
DEPT. 216—WASHINGTON 16, D. C.

YES! AT NO COST or obligation, send me the above booklet.

Name .....

Company .....

Address .....

Circle 447 on page 19

New Parts

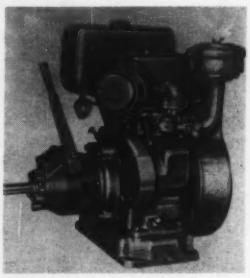
rated circuits. Units have fixed temperature coefficient, high insulation resistance, low dielectric absorption, and ability to operate under high humidity conditions and high temperature. WL-4 (shown) is 0.3 x 0.3 in. and is available in capacitances to 100 mmf at 300 v. WL-5 measures 0.3 x 0.5 in., and is furnished in capacitances to 2200 mmf at 300 v. Capacitors are rated at full voltage at 85 C, and withstand temperatures to 250 C for short-time loads of low-voltage applications. **Corning Glass Works,** Corning, N. Y.

Circle 576 on page 19

Single-Cylinder Engine

has speed range from 1600 to 3200 rpm

Model AGN four-cycle single-cylinder engine is rated 12½ hp. It has a speed range from 1600 to 3200 rpm, and piston displacement of 38.5 cu in. High torque resists



slowdowns under sudden shock loads, prevents stalling, and permits quick power recovery. Applications include farm and construction machinery, railway maintenance equipment, truck and trailer refrigeration units, and rider-type power mowers. **Wisconsin Motor Corp.,** 1910 S. 53rd St., Milwaukee 46, Wis.

Circle 577 on page 19

Oil Control Valve

for industrial oil burner installations

Type 235 adjustable-cam, lever-operated valve provides accurate metering control of fuel oil in industrial oil burner installations. Valve controls and maintains a flow ratio between two variables. Contour of the flexible sheet-metal

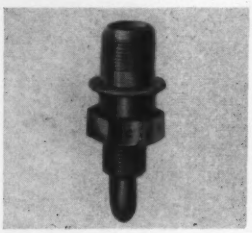
cam is adjusted by 24 screws. Cam is attached to a lever which moves it in accordance with demand motion from the other variable. Single-seated valves have ⅜-in. diameter bore. **Atlas Valve Co.**, 280 South St., Newark 4, N. J.

Circle 578 on page 19

Thermal Switch

operates in temperatures from −65 to 700 F

Hermetically sealed two-wire thermal switch, designed for use in pipes and bearings, incorporates a bimetal element and stainless-steel



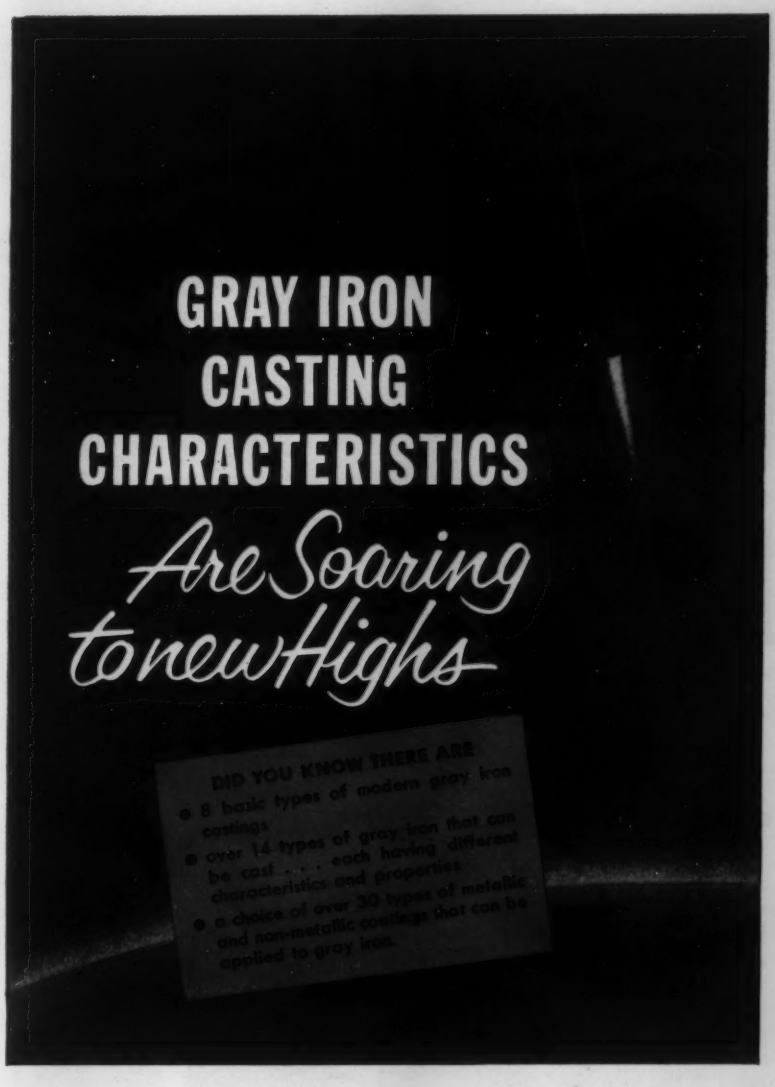
body. It operates satisfactorily in ambient temperatures from −65 to 700 F. Electrical rating is 2 amp resistive at 28 v dc or 115 v ac. Unit meets environmental, shock, and vibration requirements of MIL-E-5272A. **Control Products Inc.**, 315 Sussex St., Harrison, N. J.

Circle 579 on page 19

Power Take-Off

requires no pilot bearing

This power take-off is designed to meet long-life, heavy-duty requirements. Conventional power take-off pilot bearing has been eliminated. Heavy-duty construction, including arrangement of main bearings, can eliminate need for outboard bearing supports and flexible couplings. Belt loads up to 5000 lb are handled on well-sup-


GRAY IRON
CASTING
CHARACTERISTICS
Are Soaring
to new Highs
DID YOU KNOW THERE ARE
• 8 basic types of modern gray iron castings
• over 14 types of gray iron that can be cast . . . each having different characteristics and properties
• a choice of over 30 types of metallic and non-metallic coatings that can be applied to gray iron.

If you are on the lookout for new ways and means to improve your products *and save money, too,* investigate modern gray iron castings. Gray iron is not only the most economical of all basic components, but recent developments in new gray irons and casting techniques are elevating their utility to new highs. Today they possess a combination of essential engineering properties that cannot normally be duplicated in more expensive competitive materials. Acquaint yourself with the present and future possibilities of modern, controlled gray irons. Be sure that gray iron is making its full contribution to your products. Write for the GIFS "Summary of Specifications" today.

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GRAY IRON FOUNDERS' SOCIETY, INC.
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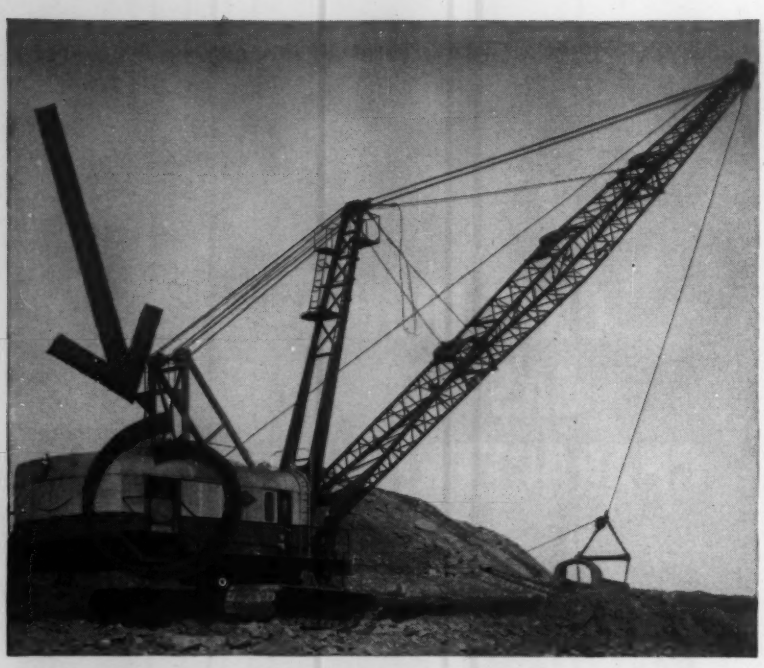
Circle 448 on page 19

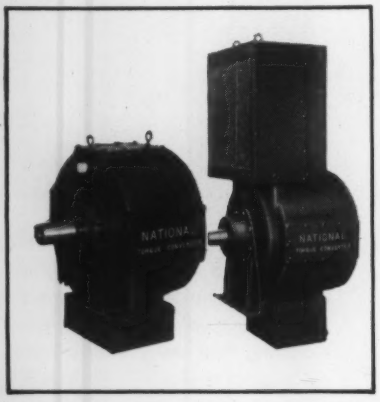


Fauzio Brothers' big Lima Dragline is "Work Conditioned" with a National Torque Converter

A lot of stamina and a lot of capacity are built into this big dragline—but they both have been profitably plussed by a National Torque Converter. With the engine operating at all times within its best speed and efficiency range, the torque converter automatically adapts the power supplied to the load conditions.

For instance—if the bucket hits a boulder and resistance builds up in the dragline, the *speed* of line take-up is automatically reduced, and the *force* of the pull is automatically multiplied. When resistance drops, speed automatically increases and pull automatically declines. Shocks and stresses are absorbed within the converter, operator fatigue is lessened, output is boosted.

These same benefits are helping users of other large equipment, too. If you have any heavy machinery driven by electric or internal combustion prime movers of from 100 to 1000 hp, and if it works under rapidly varying loads and is subjected to severe shock and strain, a National Torque Converter may provide a profitable answer to your problem of getting top output with bottom maintenance cost. *Just write:*



National Torque Converters are manufactured with or without integral cooling systems.

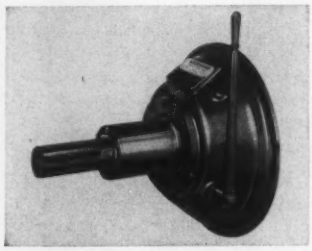
THE NATIONAL SUPPLY COMPANY

INDUSTRIAL PRODUCTS DIVISION

Two Gateway Center, Pittsburgh 22, Pa.

Pace-Setters in the progress of industrial power transmission

New Parts



ported drive shaft. Unit is furnished with single or double-plate, organic or cerametallic-faced gear-tooth drive clutches. **Borg-Warner Corp.,** Rockford Clutch Div., Rockford, Ill.

Circle 580 on page 19

Safety Valves

in sizes from ½ to 3 in.

Series 1875 top-guided, bronze pop safety valves are for steam-generator service and air or gas applications at set pressures to 300 psi at 450 F. Optically machined

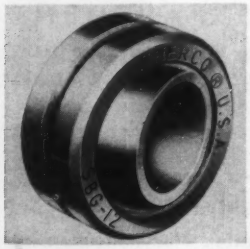
and lapped flat seat and self-aligning disc provide maximum tightness and positive shut-off. Three styles of valves have plain cap, open lever, or packed cap and lever. Sizes range from ½ to 3 in., with male inlet, female side outlet. **Farris Engineering Corp.,** 702 Commercial Ave., Palisades Park, N. J.

Circle 581 on page 19

Spherical Bearings

for aircraft and industrial use

Series of spherical bearings covers radial static load ratings from 2700 to 104,000 lb. For use in aircraft or industrial applications, bearings are available in aluminum bronze, heat-treated alloy steel, or carbon steel, all cadmium plated, and heat-



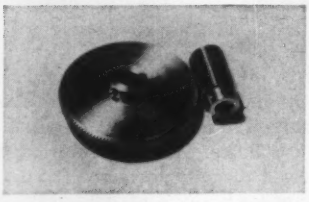
treated stainless steel. **Stephens-Adamson Mfg. Co.,** Sealmaster Bearing Div., Ridgeway Ave., Aurora, Ill.

Circle 582 on page 19

Worms and Wheels

for miniature programs and high ratio reductions

Type Q worms are stainless steel and wheels are bronze. They are available in 48 pitch in single, double, or quadruple threads.



Small pitch diameter worm permits using the combinations for miniature programs and high-ratio reduction. **PIC Design Corp.,** 477 Atlantic Ave., East Rockaway, N. Y.

Circle 583 on page 19

Transmission Belt

has minimum belt stretch

Length uniformity in Unicord belt, designed for use on all types of drives, is maintained by controlling amount of moisture in air during manufacture. Tension member consists of one ply of super-strength synthetic cord. Flex life is greater than other constructions on small pulleys because there are no plies to separate. A loop built belt, the Unicord has folded-edge construction formed by a black two-ply, straight-laid envelope cover. It is available from 4 to 6 in. wide and 100 in. to 45 ft long. **B. F. Goodrich Industrial Products Co.,** Akron, Ohio.

Circle 584 on page 19

you can
TRUST a
TROSTEL
seal
Leather Oil Seals
Rigid laboratory control PLUS 100% inspection assures Consistent Quality
Leather Packings
Synthetic Rubber Packings
Synthetic Rubber Oil Seals
When the reputation of a product depends on the unfailing performance of a seal . . . you need quality you can trust.
Here, at Trostel, quality control procedures are an integral part of the packings specification itself . . . and these carefully worked out procedures are rigidly enforced during processing and manufacture by one or more of three separate laboratories. Then, to make doubly sure, each individual packing and oil seal must pass a comprehensive visual inspection before it can be released for shipment.
We invite you to join the growing list of major equipment manufacturers who know from their own experience:
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mechanical packings
and oil seals

Circle 450 on page 19

Precisionspring CLUTCHES

10 STANDARD CLUTCHES

to cut your costs!

for OVER-RUNNING BACKSTOPPING • INDEXING

Proven in hundreds of applications—Time after time Precisionspring Over-running Clutches have outperformed other clutches at higher speeds with longer life and less maintenance—at lower cost.

10 standard models now in stock—Today you can get all the advantages of Precisionspring Over-running Clutches *right off the shelf.* Standard models in 8 to 200 lbs.-in. torque capacities are available to help you improve your product by replacing the clutching device now being used.

Get your copy of Bulletin SP-20—If you are now producing any kind of mechanism that must overrun, backstop or index you will want to check all the facts about these cost-saving Standard Precisionspring Clutches. Bulletin SP-20 gives complete engineering information. Write to the home office, 1145 Galewood Dr., Cleveland 10, Ohio—or phone GLenville 1-4800.

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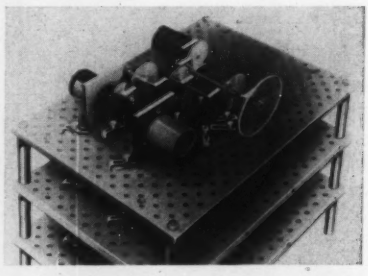
ENGINEERING DEPARTMENT

EQUIPMENT

Assembly Kit

contains electromechanical parts for breadboard models

This Servoboard kit contains mounting boards, hangers, shafts, gears, couplings, adaptors, clamps, clutches, differential, cam, and microswitches, load discs, pulse-



disc limit stops, terminal assemblies, and dial or hand-crank assemblies. Mounting board has tapped holes. Components can be screwed directly to board from the top, at any angle of assembly. No nuts are required. Mounting plates can be stacked to conserve bench space. **Servo Corp. of America,** 20-20 Jericho Turnpike, New Hyde Park, N. J.

Circle 585 on page 19

Desk Microfilm Viewer

is also an exposing unit

Redesigned Examiner machine permits viewing of engineering drawings, maps, specification sheets, personnel records, legal-size and other documents on microfilm. Viewing screen is 14 x 14 in. and lens provides five magnifications from 15 to 43X. Screen is slight-

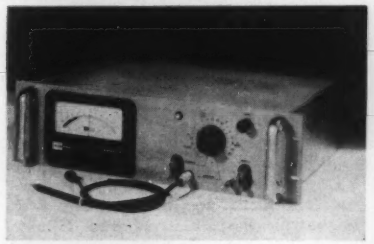
ly tilted for reading convenience at seated level. Increased lamp wattage provides greater screen illumination and higher reproduction resolution. Viewing screen area is hinged so that it is readily opened to serve as exposing area for making enlarged prints. **Dexter Folding Co.,** Filmsort Div., 50 S. Pearl St., Pearl River, N. Y.

Circle 586 on page 19

Transistorized Volt-Ammeter

34-range unit has built-in amplifier

Model 203AR is a compact, 19-in. combination dc microvoltmeter, microammeter, and low-level dc amplifier. Partially transistorized, it provides high sensitivity with drift-free stability and high input im-



pedance. Fifteen voltage ranges cover 100 mv to 1000 v full scale, and 19 current ranges cover 1 millimicroampere to 1 amp full scale. Applications include use in electronic research and development work, transistor production or circuit design, medical and biological research, metallurgy, chemistry, or wherever small dc voltages and currents are measured. **Kin Tel,** 5725 Kearny Villa Rd., San Diego 11, Calif.

Circle 587 on page 19

Nonprint Pencil

does not show on reproduction

Mars nonprint pencil has a translucent, colored lead which makes a line that drops out when a translucent original or master is reproduced by blueprint, brownprint and Ozalid. Pencil holds a fine point and supplies a rich, contrasting color that will not fade or smear. **J. S. Staedtler Inc.,** 25 Picarolis Court, Hackensack, N. J.

Circle 588 on page 19

Felt has the Guts to "SNAP-BACK"!

No doubt about it — Felt by Felters is "teased" into just the right fiber arrangement for extra resiliency and long wear.

It does not crumble under pressure or deteriorate under continuous operation. Has predictable permanent set, is not adversely affected by age, water, oil, gasoline or acid in normal concentrations. It can be used with glass, wood, metal or plastics and treated chemically to meet technical and industrial requirements.

FELT IN USE . . . Felt is widely used as filtering medium, from the respirator use shown here to filtering out impurities in oil and similar fluids. Felters Felt comes in variety of densities, has high absorption and is an effective, low-cost seal against dust and dirt.

Free Design Book

Find out about *all* the ways felt can help you in product design. Complete data in handy form, even to selection and ordering of right grades. It's yours for the asking. Send for it today: The Felters Company, 242 South Street, Boston 11, Mass.

Get the Best, Specify

FELT by FELTERS

Manufacturers of Felt and Felt Products — *Represented in All Principal Cities*

Circle 452 on page 19

DESIGNING WITH ALUMINUM

NO. 26

This is one of a series of information sheets that discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., Department PD-1, 919 No. Michigan Ave., Chicago 11, Ill.

ADVANTAGES OF ALUMINUM FOIL STRIP FOR ELECTRICAL WINDINGS

Conversions from round copper wire to aluminum interleaved strip windings are bringing improved design, better performance and lower costs to a wide range of mass production applications.

ALUMINUM RIBBON, interleaved with insulation material, has successfully replaced copper in such applications as: transformers for radio and television; motor starters and aircraft accessories; field and rotor windings for motors and generators; coils for solenoids, relays and ignition devices; chokes, filters and a vast range of similar electromechanisms and electronic devices.

Conversion to Foil Strip Offers Design Advantages

Although the design of any electromagnetic unit depends upon its specific application requirements, aluminum ribbon conductor offers several advantages to *all applications* converted from round copper wire:

1. *Reduction in void space often allows equivalent cross-section size.* Whereas round copper wires leave unfilled spaces between strands, the flat aluminum ribbons lie neatly together in a compact mass free of voids. This can often allow equivalent winding cross-section size. Where cooling ducts and layer insulation are used, the aluminum ribbon and interleaving insulation will almost always fit the same winding gap as copper.
2. *Excellent heat dissipation reduces operating temperature.* Aluminum conducts heat better than any insulation or impregnating material. A ribbon-wound coil has substantially the same temperature throughout a layer of conductor because each layer is a solid conductor and dissipates heat to the outside. Absence of voids eliminates formation of local "hot spots"—has reduced temperature as much as 100°F. This control of temperature normally allows a reduced aluminum cross-section for equal current carrying capacity.
3. *Lower area factor helps reduce cost and weight.* Because ribbon wound coils generally operate at temperatures 20 or more degrees (F.) lower than wire wound coils, it is possible to reduce the 1.64:1 aluminum-to-copper area ratio that is theoretically necessary. In actual use, area factors are about 1.5 and occasionally have been as low as 1.25, making possible weight reductions of over 50% ... with cost savings of 30 to 40% for copper wire conversions in sizes #24 or larger.
4. *Manufacturing method reduces problem of conductor tensile strength.* Because wire-drawing tensions are absent in manufacturing the slit aluminum ribbons, and because aluminum's better heat dissipation lowers coil temperatures, comparative conductor strength has little significance. Aluminum ribbon conductor is readily available and readily adaptable to high production techniques.
5. *Effective joining methods available at low cost.* A wide variety of joining techniques and equipment—all proved in thousands of high-production electrical devices—offer economy equal or better than copper for both initial cost and maintenance.

Two Design Approaches Meet Conversion Problem

The fundamental design problem in converting from copper to aluminum conductor is, of course, to provide for and accommodate the additional coil cross-section needed for equal conductivity, and at the same time provide equal dissipation of heat. Two basic approaches may be taken to this problem.

First, the conductor cross-section may simply be increased by the appropriate factor (1.5) to give the same ampere turns and resistance; or second, the wiring area may be changed to allow a better ratio of conductor to insulation where space is critical or the coil may be split and connected in series to further help this conductor to insulation ratio.

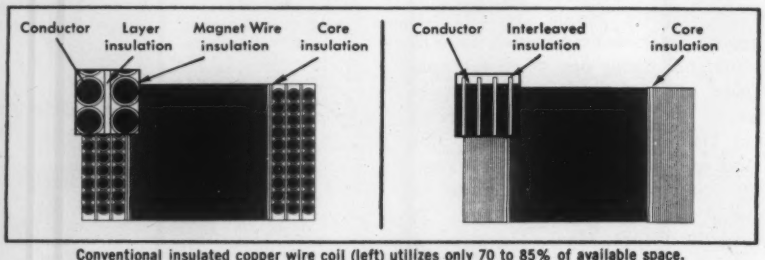
Designing for a compromise between these two approaches is favored by the physical shape of aluminum strip conductor, and allows the designer to make use of the advantages of both approaches. The aluminum ribbons are produced by slitting from foil, which may be mill-rolled to any requested thickness, and thus are available in any desired combination of gauge and width, unrestricted to standard gauge sizes. And—to the designer's advantage—the aluminum conductor proportions may be exactly determined *by the rectangular geometry* of the wiring cross-section.

Elimination of the voids between circular conductor sections together with the better dissipation of heat due to this design results in working temperatures normally about 20°F. cooler than in round wire. Some ribbon wound coils have reduced "hot spot" temperatures by as much as 100°F., and have accepted without damage excess loadings that have destroyed electromagnetically-equivalent copper wire wound coils.

When aluminum ribbon conductor is substituted for copper wire to give equal current carrying capacity and equivalent resistance, the aluminum conductor assembly is little or no larger and *sometimes smaller*—than its copper prototype.

Insulation Need Not Have High Dielectric Strength

Because the potential between successive wraps is usually low, the insulation materials between layers normally does not require high dielectric



Conventional insulated copper wire coil (left) utilizes only 70 to 85% of available space. Aluminum interleaved strip conductor coil (right) utilizes up to 97% of overall space.

strength. Condenser paper 0.00025" in thickness may be used in many applications where space is highly critical.

"Mylar"* and "Teflon"* plastics have excellent dielectric, tensile and scuffing strength. They are available in gauges down to 0.00025" and accept, without aging, higher temperatures than paper. The higher cost of "Mylar" for Class B insulation, and the still higher cost of "Teflon" for Class H insulation are justified for conversion of high operating temperature coils.

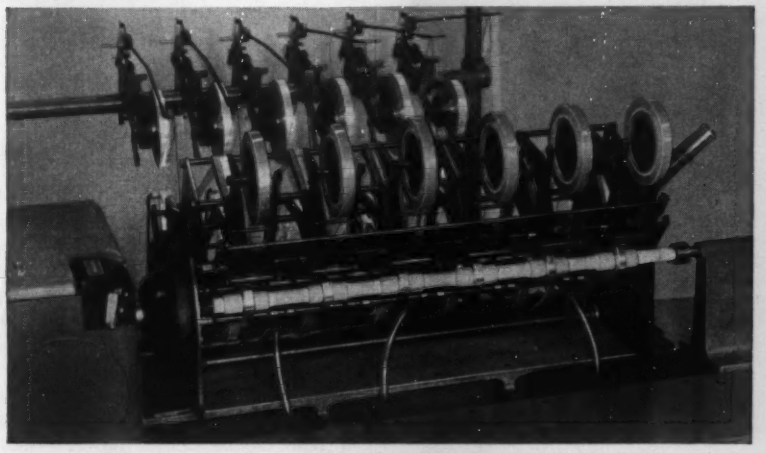
Fixed coatings such as resins and enamels are efficient and eliminate separate interleaving. Although they are not commercially available at this time, should they become more readily available in the future, this factor would further reduce material cost.

Anodized conductor similarly needs no separate insulation, resists temperatures up to 750°F., and eliminates the need for separate interleaving materials. Extreme care is necessary to prevent edge crazing of the anodic coating during the winding operations. The anodic coating is inherently porous and requires sealers against moisture. Such sealers are presently limited to a maximum temperature of about 400°F.

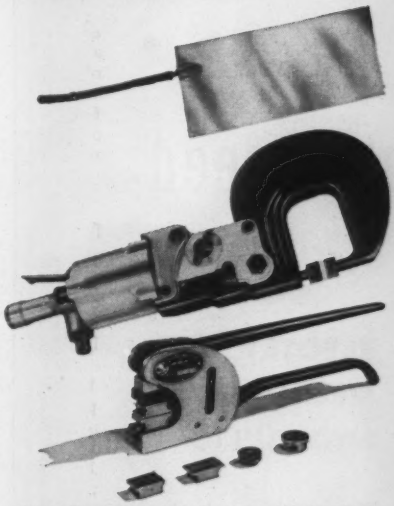
The strip insulation lowest in weight and cost is condenser tissue of suitable gauge. The paper is limited by a tendency to become brittle after lengthy exposure to temperatures above 250°F., but otherwise is an excellent general purpose insulator. Because of its natural porosity, it may be readily impregnated with resin sealers for protection against moisture, or with sealer-adhesive materials to bind the interleaved coil into an integral unit.

Most of the existing machinery for handling single-wound, heavier size conductors can be adapted readily to the use of aluminum ribbon by adding little more than an unwinding reel, a suitable tension device and guides for the insulation and aluminum strip.

Equipment for multiple winding of smaller coils often is too specialized for easy adaptation, but usually may be converted by more detailed alterations. In present practice, both conductor ribbons and insulation strips are wound from reels of pre-slit material.



Modern foil coil machine designed specifically for aluminum ribbon coil windings. (Universal Winding Company, Providence, R. I.)



Above: Tinned copper wire pressure welded to aluminum foil. **Below:** Koldweld tools made by Utica Drop Forge and Tool Division of Kelsey-Hayes Company.

*Dupont trade names.

Tested Joining Methods Offer Economy, Versatility

The joining of round, flat, and stranded leads of aluminum or copper to ribbon conductors of aluminum has been accomplished in a variety of ways. Soldering or brazing of leads and terminals may be accomplished by use of suitable aluminum fluxes and solders, by ultrasonic soldering techniques, or by the use of fiber-glass brushing in conjunction with recommended aluminum solders on the heavier gauge materials.

Cold or hot pressure-welding is an extremely economical method by which the metals are pressed into plastic-flow merging of surfaces to give a true weld. Fusion welding by torch flame or electric arc may also be used for the heavier gauge materials. Standard crimping procedures have been used effectively although the ribbon conductor shape also permits punching to receive wide flange connecting parts without need for crimping.

Where dissimilar metal joints are used and are susceptible to high humidity conditions, suitable resin sealers may be applied at the joint to minimize the possibility of galvanic corrosion.

The operating and cost efficiencies of aluminum strip conductor are most marked when replacing copper wire of #24 AWG or larger, but savings have been realized by conversions through #30 gauge. Economies in conductor cost, including insulation, have been recorded from 30 to 40%.

Kaiser Aluminum does not manufacture electromagnetic coils or insulation materials, but has wide availabilities of aluminum ribbon conductor and a special technical staff to assist coil manufacturers and users in all details relating to the use of its conductor materials in their products. Inquiries for such assistance are welcomed and sample coils can be fabricated to customer specifications for their evaluation in possible conversions.

For immediate attention to your request for this technical service or samples, or for more detailed information, contact the Kaiser Aluminum sales office listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 22, Calif.

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Recent Books

Medium Size Transformers. *By Samuel Heller, American Rectifier Corp., New York City;* 208 *pages,* 9 *by* 12 *in., paperbound; published by Datarule Publishing Co., Box* 69, *Scarsdale, N. Y.; available from* MACHINE DESIGN, $25.00 *postpaid.*

This book presents step-by-step instructions for designing, reconnecting, and testing all types of transformers rated at 100 KVA or less. A separate section covers design of potential and current transformers and saturable-core reactors. Need for computations is completely eliminated through use of specially designed charts.

All technical information is reduced to simple language, making it possible to design power transformers from "scratch," new windings from existing cores, and to convert ordinary small transformers into auto transformers many times larger. Other topics include design of a starting compensator and dc balance core for 3-phase winding.

Government Publications

Guide to Design of Electronic Equipment for Maintainability, WADC Technical Report 56-218, PB121439. *By John D. Folley Jr. and James W. Altman, both of American Institute for Research;* 174 *pages,* 8¼ *by* 10¾ *in., paperbound; published by Wright Air Development Center; available from Office of Technical Services, U. S. Dept. of Commerce, Washington* 25, *D. C.;* $4.50 *per copy.*

This report presents design practices recommended for maximizing ease of maintenance of electronic equipment. Factors to be considered in planning for maintainability are reviewed, and steps in designing a maintainable system are presented.

Other topics of the report include planning factors, design schedules, and recommended char-

acteristics for maintainable equipment.

In 1956, MACHINE DESIGN published a series of 12 articles based on the contents of this report before its publication in book form.

Atomic Energy Commission Research Reports Index, Price List 27. *Available from U.S. Dept. of Commerce,* 100 *Union Commerce Bldg. Annex,* 1100 *Chester Ave., Cleveland* 14, *Ohio.*

This price list is a cumulative listing of all AEC research reports for sale by OTS. Included is a guide to Russian scientific periodical literature.

Standard Samples, A Catalog of Reference Materials, NBS Circular 552. 24 *pages,* 8 *by* 10 *in., paperbound; available from U.S. Dept. of Commerce,* 100 *Union Commerce Bldg. Annex,* 1100 *Chester Ave., Cleveland* 14, *Ohio,* $0.25 *per copy.*

This book contains a descriptive listing of various standard samples issued by the National Bureau of Standards. Included are schedules of weights and fees and directions for ordering. Summarized tables of analysis are presented to indicate type of standards of composition available.

NACA Technical Series. *Each publication is* 8 *by* 10½ *in., paperbound; copies available from National Advisory Committee for Aeronautics,* 1924 *F St., N.W., Washington* 25, *D.C.*

The following Technical Notes are available:

3842. Creep Behavior of Structural Joints of Aircraft Materials Under Constant Loads and Temperatures—53 pages.

3972. Effect of Frequency and Temperature on Fatigue of Metals—15 pages.

3976. Rupture Strength of Several Nickel-Base Alloys in Sheet Form—24 pages.

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3993. Bursting Strength of Unstiffened Pressure Cylinders with Slits—21 pages.

3994. Static Strength of Cross-Grain 7075-T6 Aluminum Alloy Extruded Bar Containing Fatigue Cracks—25 pages.

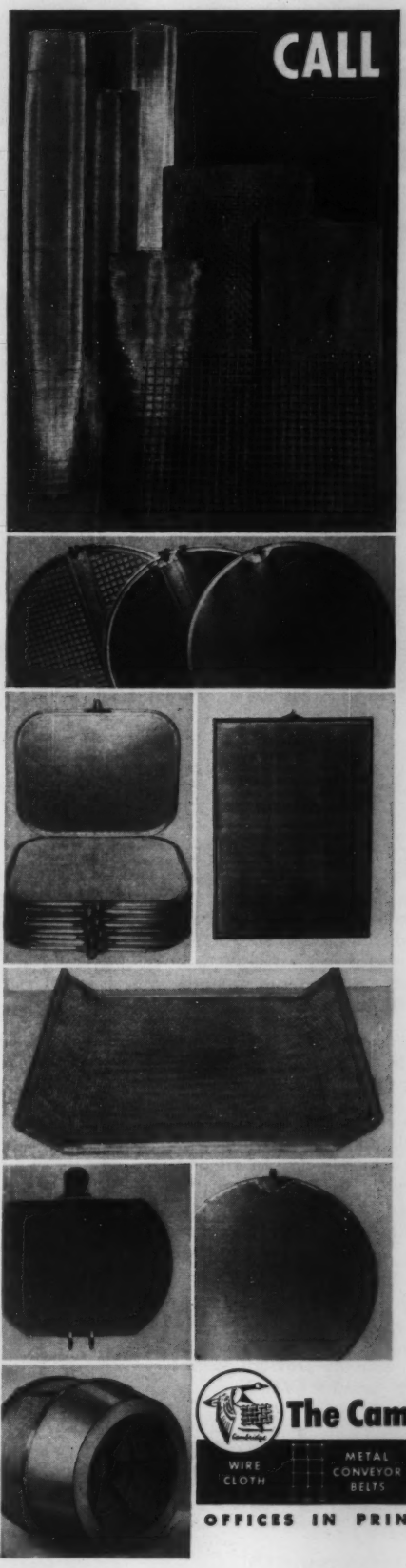
4000. A Phenomenological Relation Between Stress, Strain Rate, and Temperature For Metals at Elevated Temperatures—19 pages.

4003. A Variational Theorem for Creep With Applications to Plates and Columns—23 pages.

4009. Some Research Results on Sandwich Structures—12 pages.

4014. Recent Research on the Creep of Airframe Components—12 pages.

4019. Some Observations on Stress-Corrosion Cracking of Single Crystals of AX61X Magnesium Alloy—23 pages.



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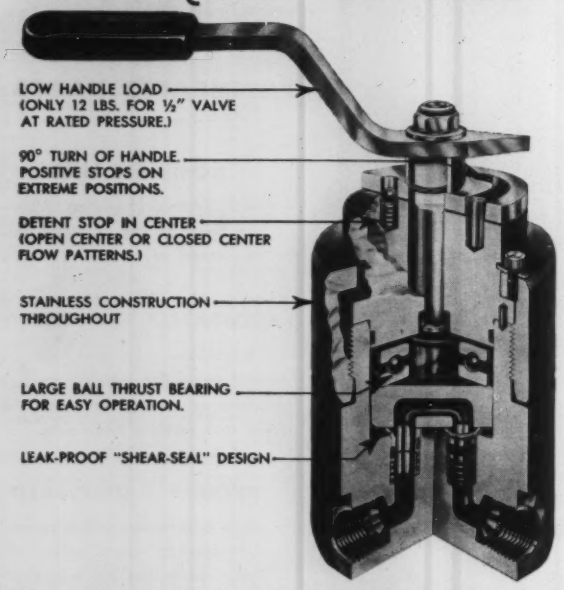
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This highly successful principle of extreme pressure control is fully described in "Shear-Seal" bulletin BVM-2.

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NOTEWORTHY

Patents

Planetary Overdrive Transmission

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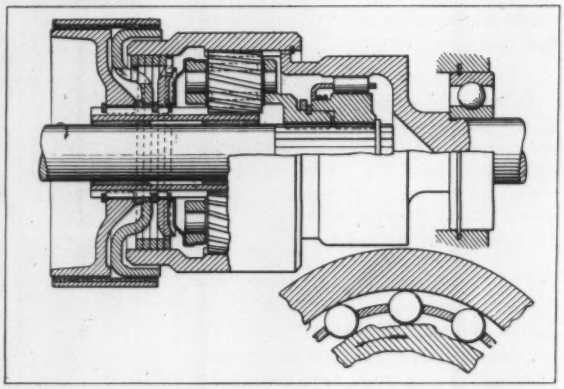
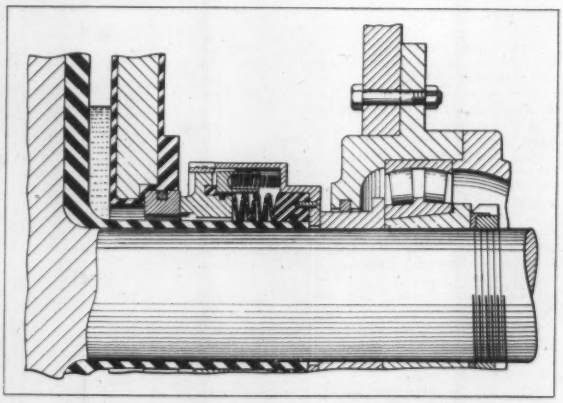


Mechanical Seal



Metal seal components are isolated from process fluids in an external-type mechanical seal. Typical

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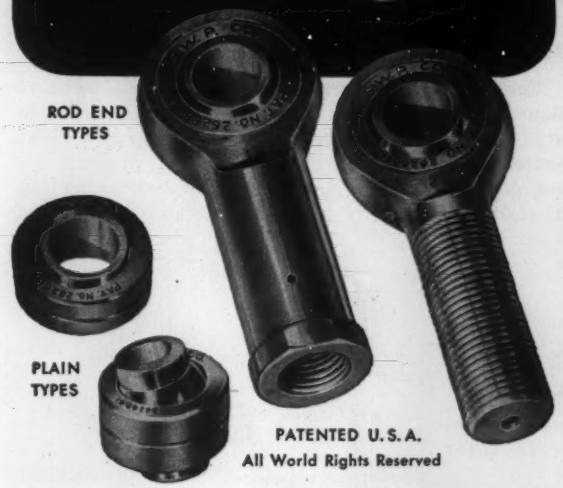

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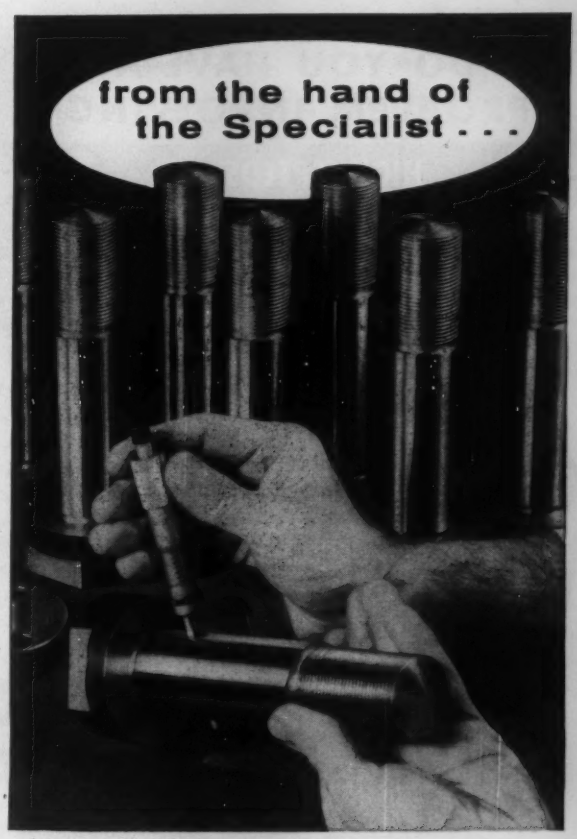

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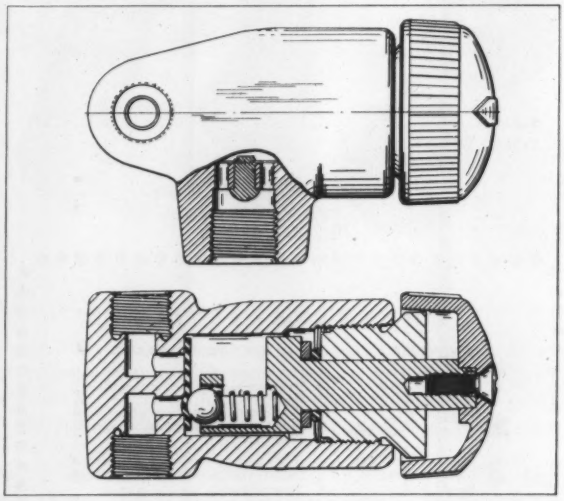
Noteworthy Patents

application is for sealing submerged-roll shafts in electroplating tanks containing acids or caustics at temperatures to 200 F. Comprising a ceramic stationary seat, mating with a powdered-alloy-impregnated, resin-base rotating washer, the seal employs a machine-cut Teflon bellows to separate the process fluid from metal seal parts. Design provides automatic compensation for axial motion of shaft or tank wall. *Patent* 2,758,856 *assigned to Crane Packing Co. by Frank E. Payne and Paul T. Haake.*

Throw-Over Valve

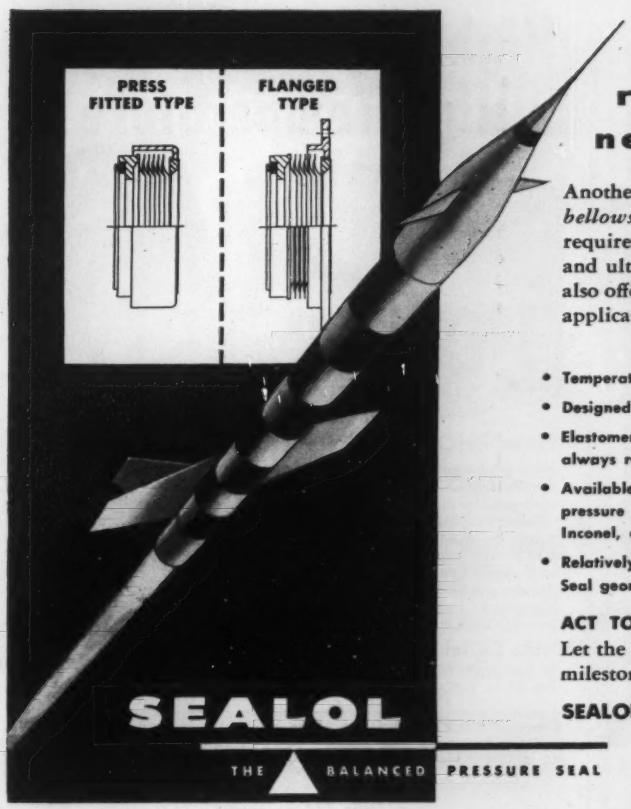
For use in high-pressure fuel systems, such as liquefied petroleum-gas installations, a manually operated throw-over valve permits quick, leakproof switching of the system from one high-pressure gas source to another. Spring-loaded ball, bearing against a resilient sealing disc that separates the central



valve chamber and the source ports, is rotated about the valve axis to determine source that is connected to the system. Should source pressure fall below system pressure, the sealing disc acts as a check valve, blocking any flow of air into the central valve bore. Formation of an explosive mixture in the system is thereby prevented. *Patent* 2,752,948 *assigned to Weatherhead Co. by Theodore A. St. Clair.*

Variable-displacement sinusoidal drive mechanism, for use with function generators, phase shifters, etc., provides linear motion with low friction. Use of antifriction-journaled spur gears and lever arms reduces substantial friction inherent with other sinusoidal-motion devices, such as the Scotch Yoke. *Patent* 2,800,029 *assigned to The Martin Co. by Alfred S. Vail.*

Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.



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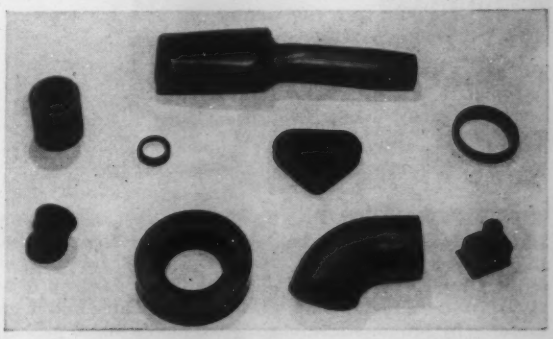

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problem:

find a low-friction seal that positively seals at extremely low pressures

new answer:

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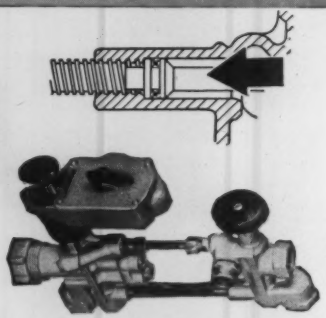
evidence:



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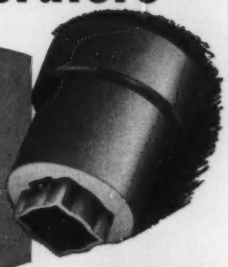

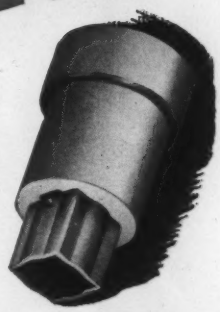

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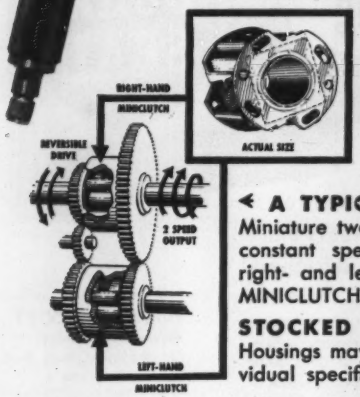

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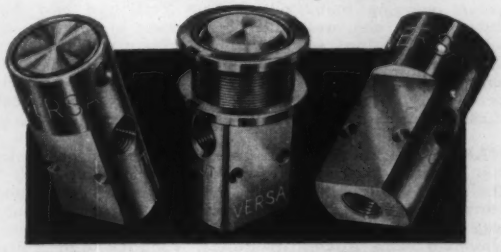

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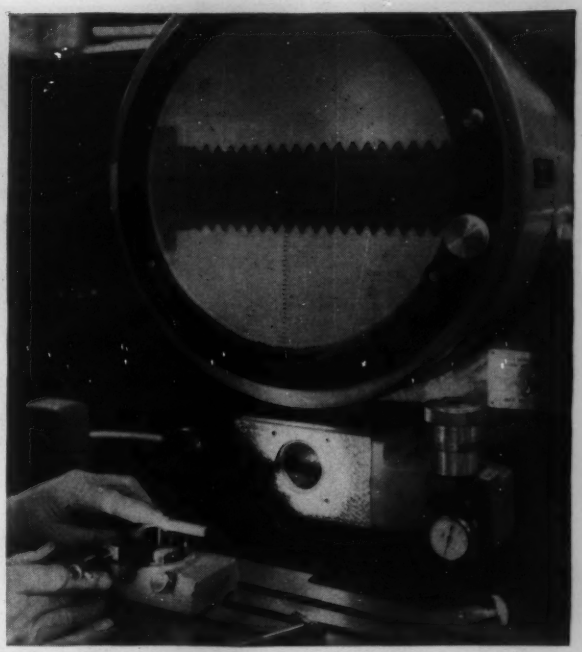

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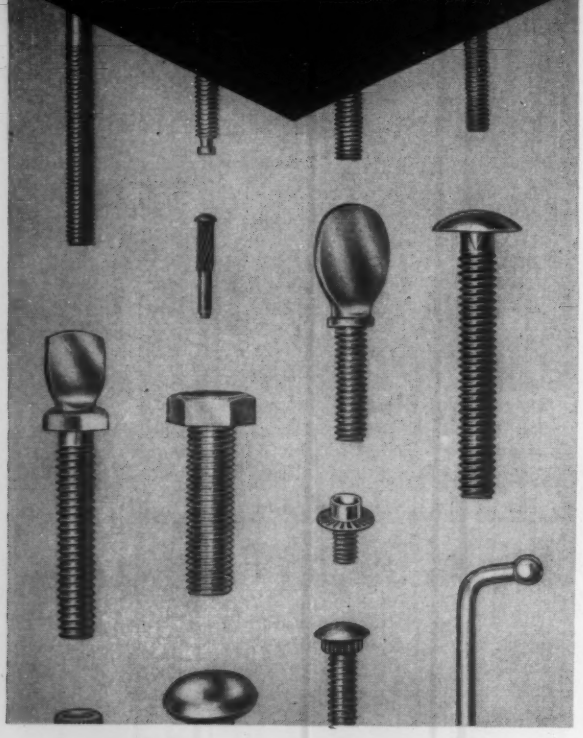

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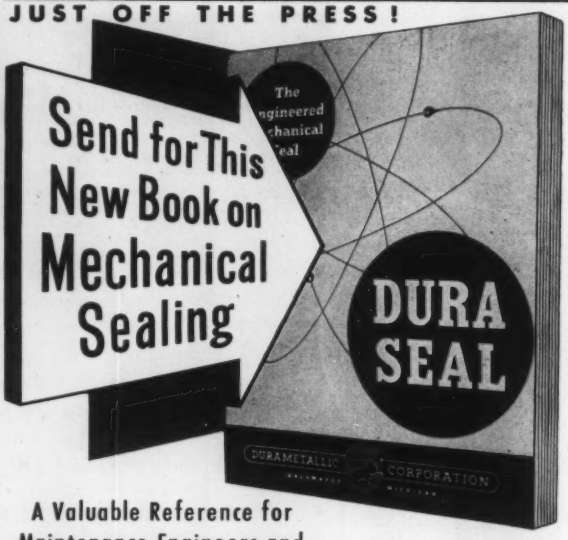

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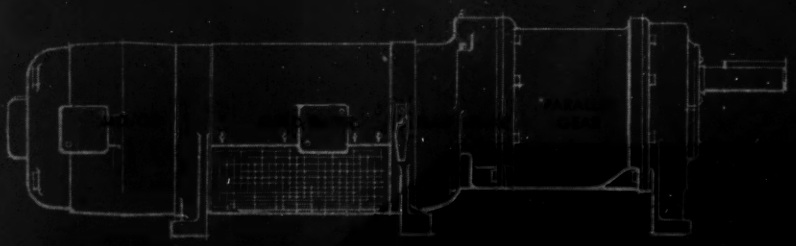

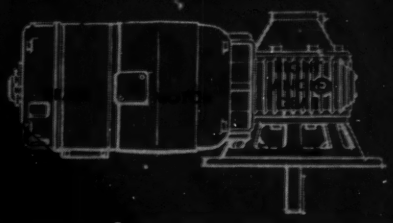

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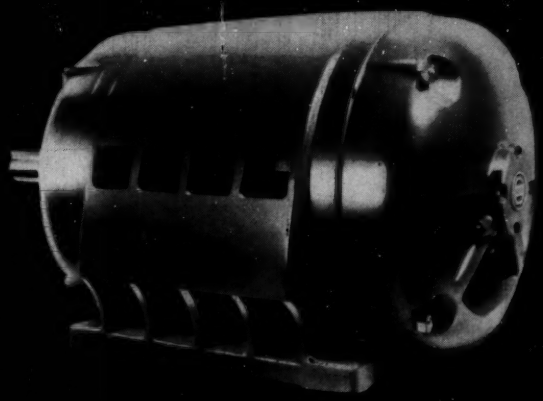
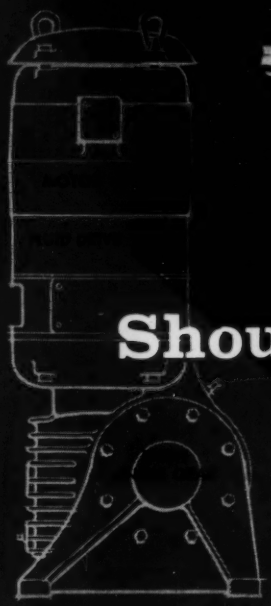
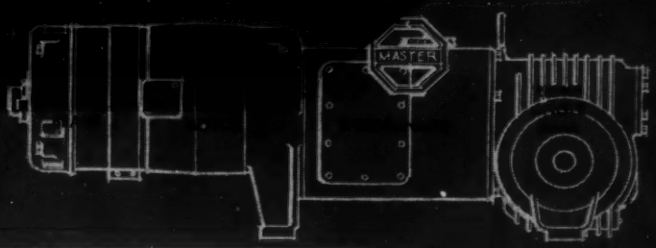




Should meet their Master



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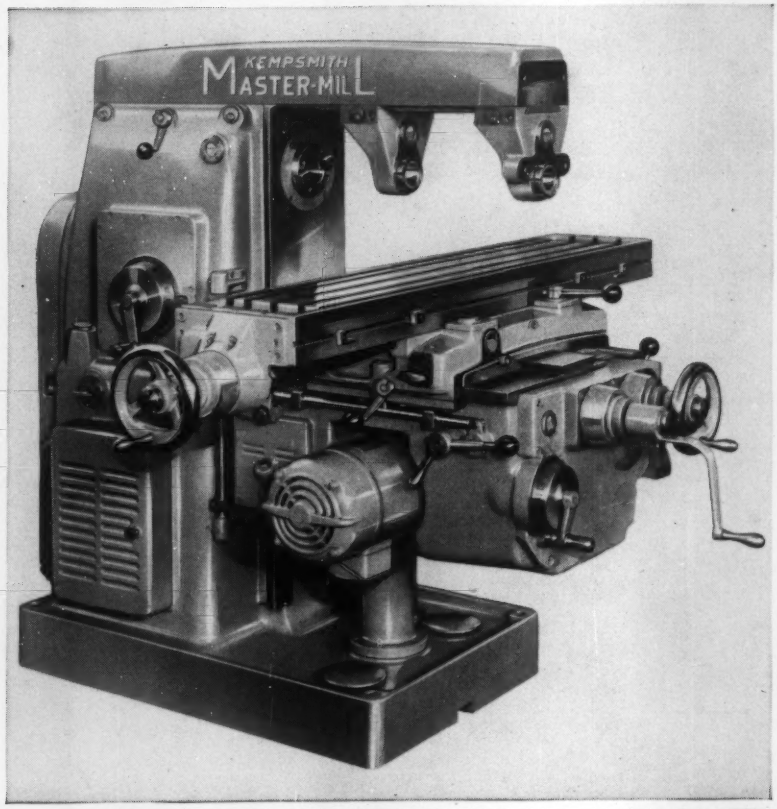
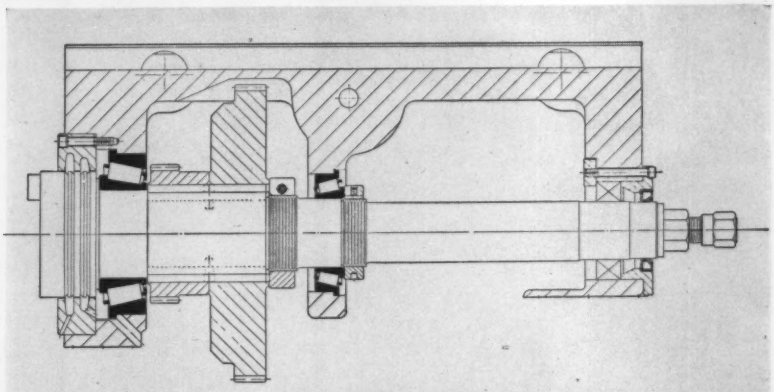
MASTER ELECTRIC MOTORS

THE MASTER ELECTRIC COMPANY, Dayton 1, Ohio

Circle 402 on page 19

New! Completely redesigned milling machine switches spindle to TIMKEN® bearings





KEMPSMITH MACHINE COMPANY mounts the spindle of their new Kempsmith Master-Mill milling machine on Timken tapered roller bearings to hold spindle in rigid alignment.

THIS Kempsmith Master-Mill, made by Kempsmith Machine Company, is a brand new, improved model—designed to meet new demands for higher production, lower milling costs. Kempsmith switched to Timken® tapered roller bearings on the new Kempsmith Master-Mill to offer users their many advantages on the spindle, on the table leadscrew, on elevating pinion, and cross feed screw.

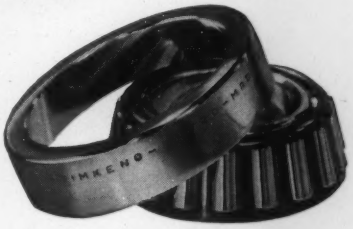
Kempsmith reports that Timken bearings are easier to install and adjust, have greater load capacity in small space, are much easier to preload.

Timken bearings hold the spindle in rigid alignment, meeting the requirement of "zero end play over a 24 to 1500 rpm speed range." Tapered construction lets Timken bearings take the radial and thrust loads encountered by a milling machine spindle, in any combination.

Timken bearings were specified, too, because of the heavy shock loads induced by the milling cutter—shocks further amplified by interrupted cuts. Rollers and races in Timken bearings are case-carburized, with tough, shock-resistant cores under hard wear-resistant surfaces. They'll *take* heavy shock loads! And Timken bearings give extra load-carrying capacity with their full line contact between rollers and races.

Geometrically designed for true rolling motion, Timken bearings are precision-manufactured, under rigid quality controls, to conform to their design. We even make our own steel, something no other American bearing maker does. Buying or building machines like this? Look for the trade-mark "TIMKEN" on every bearing! The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



TIMKEN TAPERED ROLLER BEARINGS ROLL THE LOAD

TRADE-MARK REG. U. S. PAT. OFF.

See the next Timken Televent hour, "The Innocent Years" over NBC-TV, Thursday night, November 21st.

Circle 403 on page 19